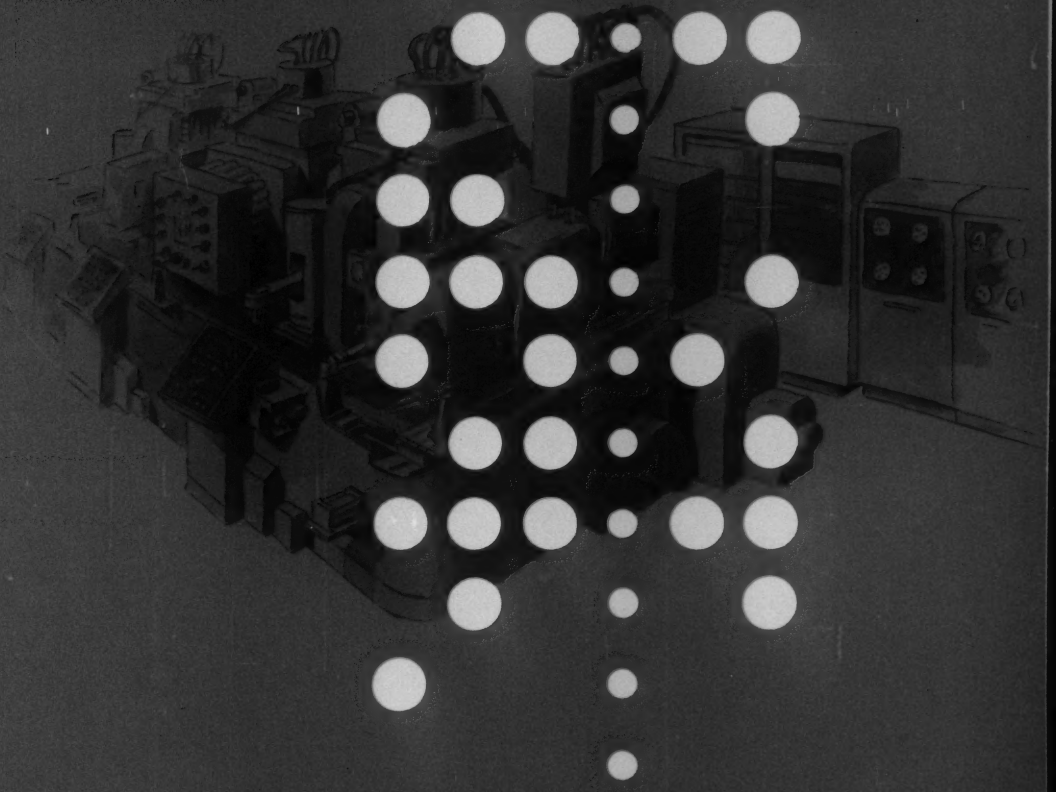
AUTOMATION

AUGUST 1960



PROJECT 60

Numerical Control

THE MAGAZINE OF AUTOMATIC MANUFACTURING OPERATIONS

- Mechanized Order-Picking System
- Drilling and Pinning Gear Units
- Key Codes Control Parcel Sorting
- Parts Loader Cuts Riveting Time

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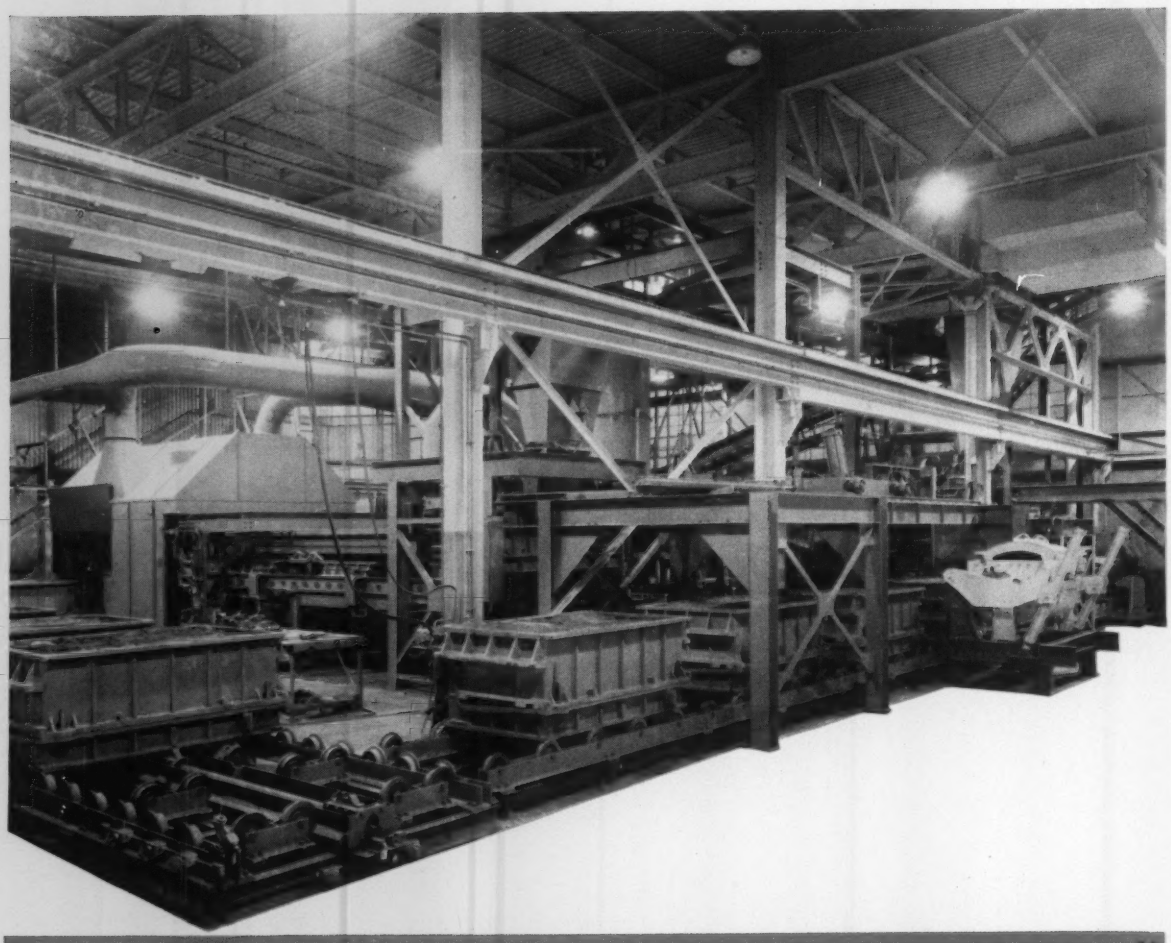
A PENTON PUBLICATION



another example of Planet Versatility...

NEW AUTOMATIC MOLD HANDLING SYSTEM

PRODUCES SEVENTY-TWO 14,000-LB. MOLDS PER HOUR

This new automatic bathtub mold handling system is one of the largest and most advanced systems in existence. The system has a capacity to turn out seventy-two 14,000-pound molds (includes flasks, sand and casting) per hour and requires only seven operators.

Engineered and fabricated by Planet Corporation and installed in Universal/Rundle Corporation's Camden, New Jersey, foundry, this new automatic bathtub mold handling system has achieved several "firsts." They are:

- First to be completely shuttle-indexed.
- First to use weights rather than clamps.
- First to incorporate automatic sand metering.
- First to index flasks through shakeout.

Custom designed systems such as this have helped build Planet Corporation's reputation throughout industry as a versatile organization . . . as an organization with solutions to the most perplexing materials handling and automation problems. Let Planet demonstrate how "PV" —Planet Versatility—can help you solve your problems . . . you'll find it pays to plan with Planet.

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- Engineered Handling Systems
- Automation Equipment
- Mill & Foundry Equipment

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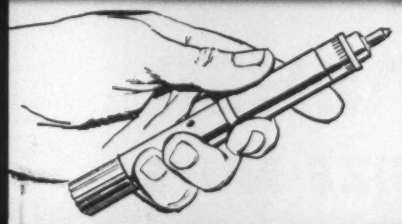
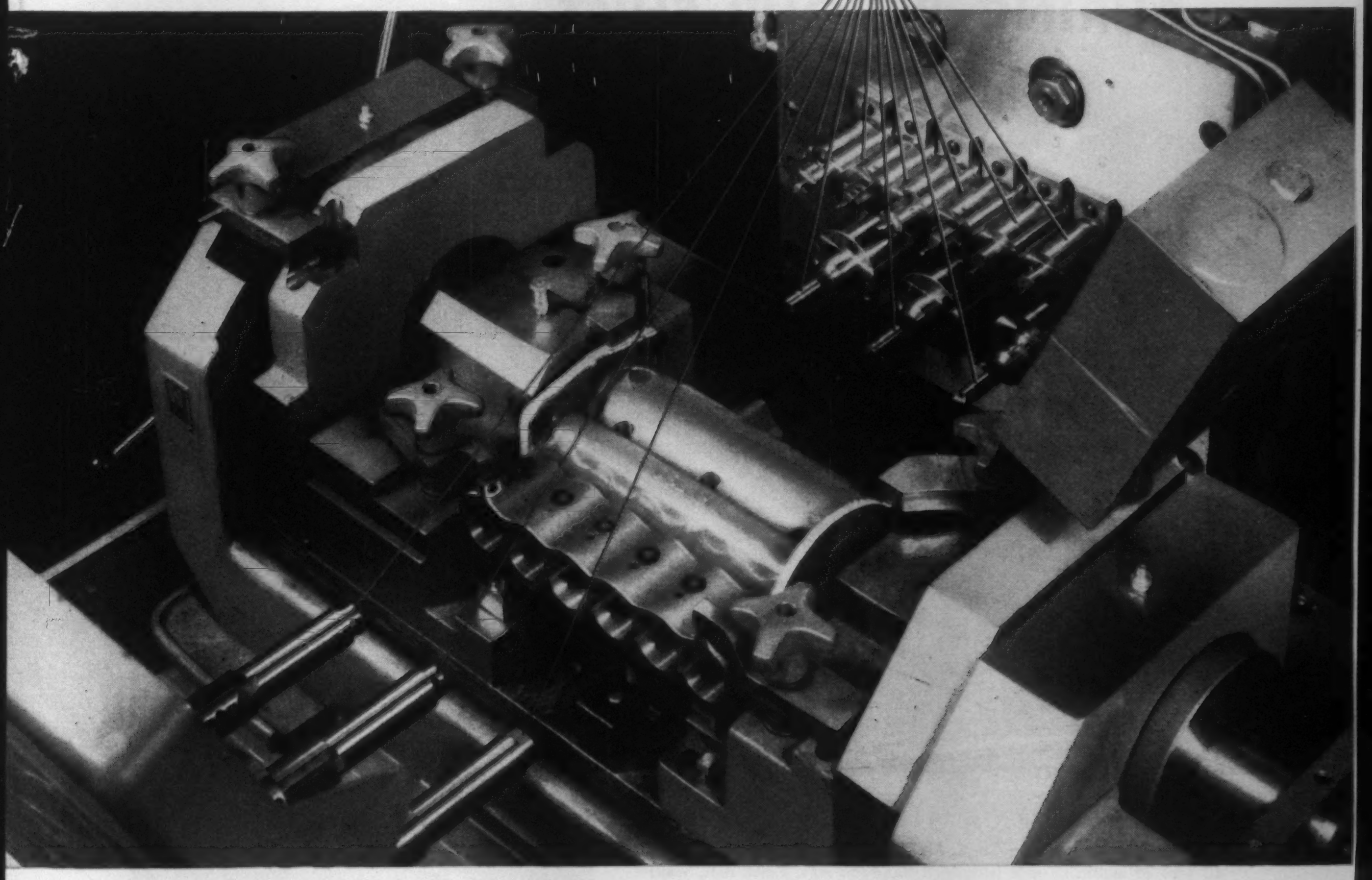


12 HEADS
are better than one



Heald Bore-Matic finishes up to 27 DIFFERENT SURFACES at a single loading

• In the setup shown above, 27 surfaces of 15 bores are done on one machine at a single loading—a Heald Model 222 Bore-Matic with Multi-Spindle heads with a trunnion type fixture. Six deep 3-step bores are done with the three left-hand heads with only one index of the cross slide. After indexing the fixture to hold the work vertical, nine right-angle bores are done at a single pass with the right-hand heads. The same machine also handles four-barrel pump housings, simply by removing one of the left-hand spindles and three of the right-hand spindles.

On multiple-hole Borizing jobs such as this, interchangeable Multi-Spindle Red-Head boringheads permit many operations to be combined on a single machine, with minimum indexing of the work and positive spacing between bores. Your Heald engineer will be glad to give you complete information.

It PAYS to come to Heald

MMT-PE

THE HEALD MACHINE COMPANY

Subsidiary of The Cincinnati Milling Machine Co.
Worcester 6, Massachusetts

Chicago • Cleveland • Dayton • Detroit • Indianapolis • Lansing • Milwaukee • New York • Philadelphia • Syracuse

HEALD

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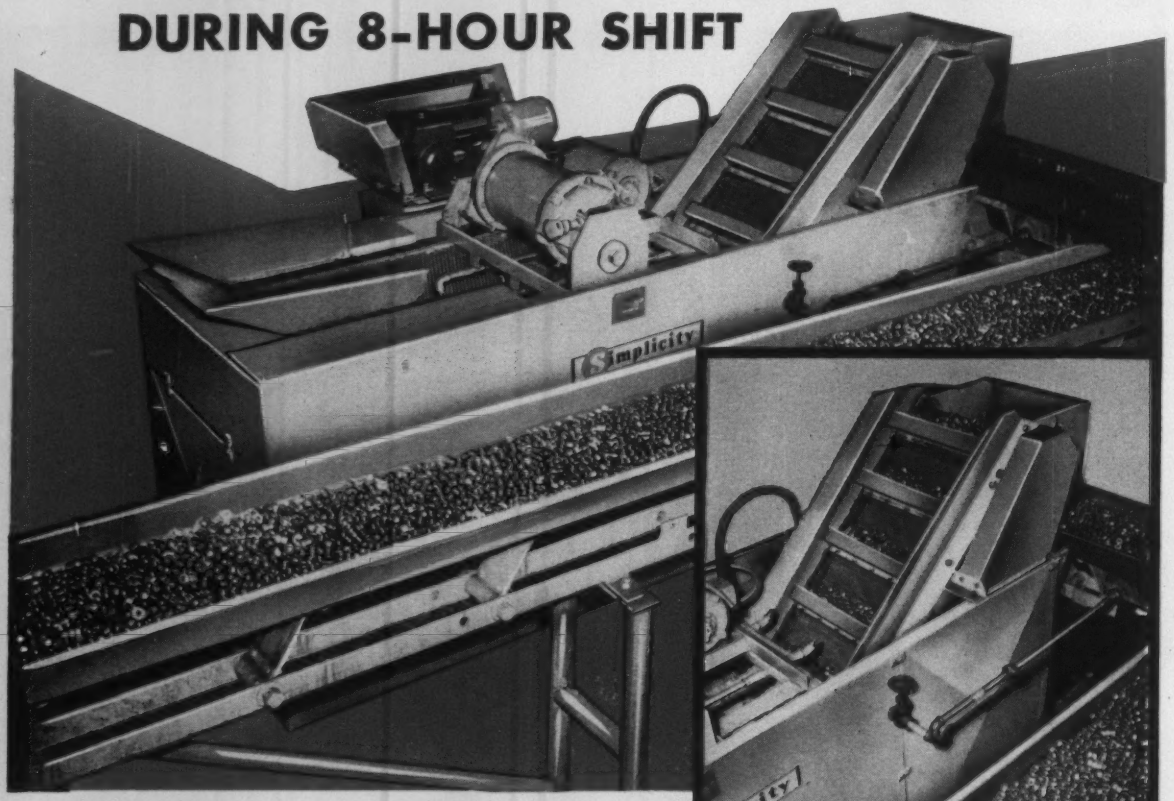
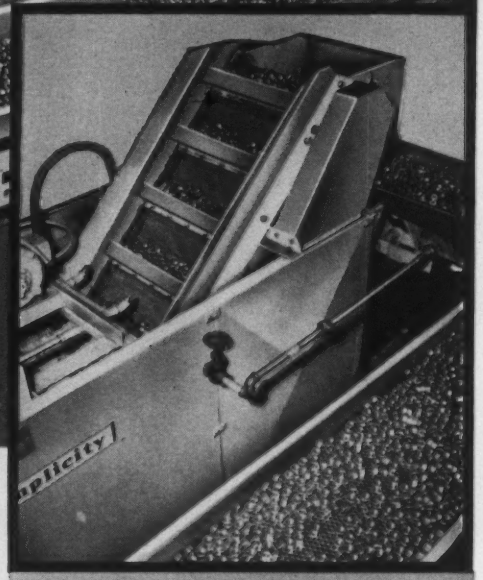
SIMPLICITY VIBRA-WASHER

CLEANS 40 TONS OF MULTI-SIZE NUTS DURING 8-HOUR SHIFT





Close view of Vibra-Washer flight conveyor and Model 36 conveyors, showing the high production capacities characteristic of all Simplicity equipment.

Decker Nut Manufacturing Corp., Albion, Michigan, is cleaning almost 40 tons of multi-size nuts (standard hexagon nuts, clinch nuts, weld nuts, pipe plugs, etc.) per 8-hour shift with the versatile Simplicity Vibra-Washer. A constant flow of nuts is fed into the Vibra-Washer vibrating assembly where, after continuous and thorough agitation in an oleum solution, the nuts are automatically elevated, contamination-free, by the flight conveyor onto a series of Simplicity Model 36 Conveyors. Here the nuts are partially dried and just the right amount of the cleaning solution is maintained for sufficient rust protection, thus eliminating an added operation. Nuts are then weighed, packaged and ready for shipment. These nuts range in size from ¼" to 1". The Vibra-Washer, however, can handle most parts up to 6 inches in size. Cleaning costs have dropped sharply at Decker Nut Manufacturing Corp. since the installation of the one-man-operated Simplicity Vibra-Washer.

For all parts conditioning jobs, the Simplicity Vibra-Washer offers many advantages. This labor-saving washer is versatile and adaptable to many operations. It involves no loading or unloading of work baskets and is available for single- or multi-stage washing operations and parts conditioning jobs and has an adjustable capacity up to 10,000 pounds per hour. The Vibra-Washer can be equipped with gas, steam or electric immersion heating elements for cleaning operations that require heated solutions. For complete details on the new Simplicity Vibra-Washer, write today for Bulletin 107.

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Vol. 7 — No. 8

AUTOMATION®

A PENTON PUBLICATION

The Magazine of Automatic Manufacturing Operations

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Numerical Control, 70

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automation outlook

NUMERICAL CONTROL

". . . Considered in a historical perspective, numerical control is part of a general long term industrial trend of obtaining more efficient and economical production through detailed planning for manufacturing at higher levels within an organization . . . . numerical control encompasses a broad range of situations in which the primary functions of automatically operating equipment are capable of being preplanned in sufficient detail, organized, and described in an unequivocal form suitable for immediate and/or direct use by the equipment . . . . management obtains improved production by, in effect, moving closer to the manufacturing operation . . . . Numerical control embraces more than control of machine tools by numbers—testing, batching, inspection, and assembly are but a few of the other areas where numerical controls are applied . . . . For bona fide use in the manufacturing world, numerical controls must pass the universal test—advantages must exceed disadvantages . . . . Consensus, of people informed on the subject, appears to be that advantages will exceed disadvantages and lead to further use of numerical control in manufacturing . . . ."—*J. H. McRainey and L. D. Miller, associate editors,* *see page 70.*

FLEXIBLE AUTOMATION

". . . The rapid development of automatic, program-controlled machine tools—capable of turning out highly-accurate, finished machining of complex pieces under punched-tape instructions—clearly indicates that automation applies to the job shop as well as the production line. In the light of growing competition for the world's markets, including our own, this kind of flexible capacity is of the utmost importance to manufacturers everywhere. It is insurance that they will lead, not merely meet, competitive demands in the future . . . ."—*R. Paxton, president, General Electric Co.*

PROFITS FROM CONTROLS

". . . It might be said that the demand for gas is as variable as the weather. Yet the pipeline must deliver gas unfailingly, and on time, from the wellhead to the market place, hundreds and even thousands of miles away, in the volumes demanded. Profits are possible only when this problem is met efficiently. Completely reliable controls systems on the prime movers assure continuous operation, and at the same time provide protection from damage which would result from abnormal conditions or minor malfunctions . . . ."—*W. D. Miller, vice president and general manager, Fulton Sylphon Div., Robertshaw-Fulton Controls Co.*

BASES FOR SUCCESS

". . . American industry could not have achieved the measure of success it enjoys today without the rapidly-expanding new technologies of instrumentation and automation. The constant improvement of manufacturing techniques and processes, the creation of new and better job opportunities, and the introduction of thousands of new and improved products in the past ten years reflect the widespread introduction of new advances in instrumentation and automation . . . ."—*D. G. Mitchell, president, General Telephone and Electronics Corp.*

AUTOMATION

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BPA NBP

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. . . Fluid Power news

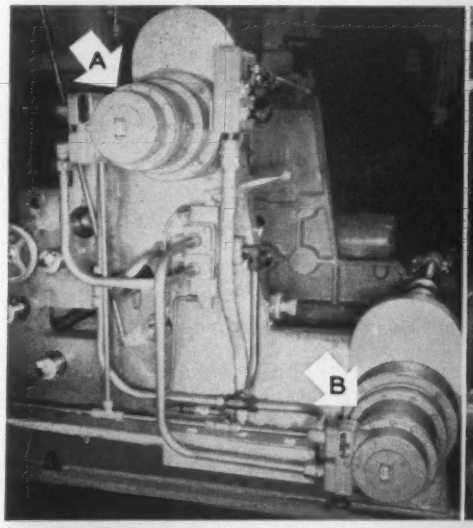
REPORT No. 12,300 HIGH PERFORMANCE WINDER DRIVES

From Oilgear Application-Engineering Files

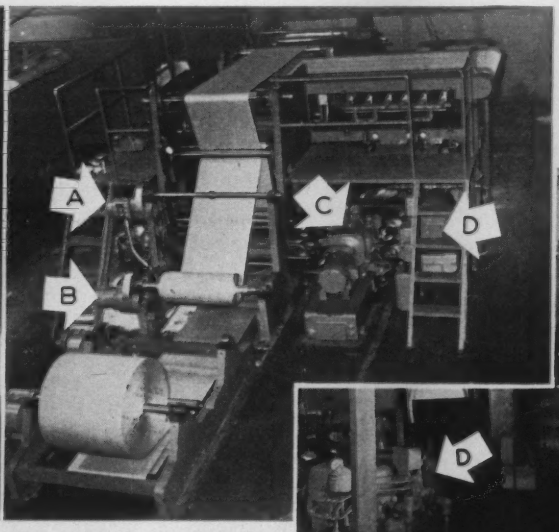
HOW OILGEAR PROGRESSIVE ENGINEERING PACES IMPROVEMENTS ON "BEMIS" MACHINES

CUSTOMER: *Bemis Bro. Bag Company, St. Louis, Missouri*

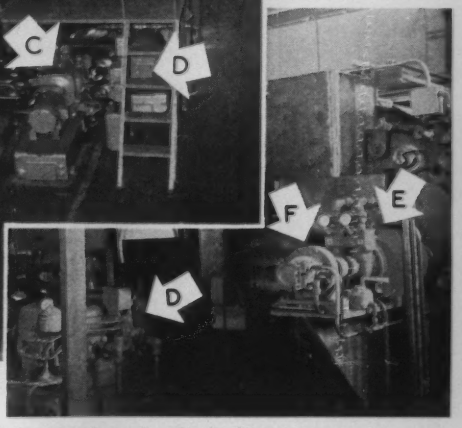
DATA: To efficiently produce the wide scope of paper, cloth, and polyethylene "Flexible Packaging" for which they are famous, "Bemis" designs and builds their own production machinery. Basically, "Bemis" machines are roll-fed, multi-color printing presses capable of very close register . . . operating from inching speeds of 15 fpm to running speeds of 400 to 1000 fpm. Press runs range from 1000 to 1,000,000 bags. Being roll-fed presses, winder drives and controls were a major problem, as ratios of 5:1 up to 10:1 from core to finished roll diameter are not uncommon. Paper widths vary from 10″ to 56″, with roll weights from 1000 to 2000 lb. "Bemis" specified that their winder drives must be compact; easy for shop, maintenance, and operator personnel to adjust, maintain, and understand. All electrical controls must be simple, with standard components preferred. Each machine to have one main control panel, and three or four remote, push-button panels — with some constant indication of load and tension as a desirable feature. Long, trouble and maintenance-free life was also of prime importance along with ease in installation.



Close-up of face-mounted, Oilgear Type "H" Fluid Power Motors (A, B), geared to rewind spindles of newest "Bemis" machine, shown center. Oilgear Type "D" Pump on "Power-Pak" (C) — center photo — supplies Fluid Power for rewind drive.



Newest "Bemis" press during "trial runs" prior to installation. Rewind motors (A, B) to left. Two Oilgear "Power-Paks" (C, D) with Oilgear Type "D" Pumps and Controls can be seen "tucked away" under the dryer section.



View "around-back" of new "Bemis" press dryer section, showing Oilgear Type "D" Pump and Controls on "Power-Pak" (D) which supplies Fluid Power to Oilgear Type "H" Motor (E) for main press drive. See "Note" below on Oilgear Pump (F), direct-coupled to tail-shaft of Motor (E).

SOLUTION: Through a program of constant improvement and engineering teamwork, Oilgear *Fluid Power* Drive and Control Systems have so successfully paced requirements for more efficient production equipment that "Bemis" plants in 16 cities now have 48 machines equipped with Oilgear winder drives. Dancer roll controls are used on 39 . . . 9 more recent installations have "*HYTAC SYSTEM" drives. Two newest machines (one shown above) have Oilgear Type "D" electrohydraulic servo controlled main press drives, and hydraulic servo controlled winder drives. One reason for this ever-increasing use of Oilgear "Any-Speed" drives has been clearly stated as follows: *"We put them in and forget about them . . . some have been operating for over 11 years without service or repair — many loaded to maximum capacity — others have had no oil change in five years"* . . . proof of the statement heard in all industry — *"For the lowest cost per year — it's Oilgear!"* One "Bemis" installation using a HYTAC SYSTEM winder drive handles 40 to 70-lb kraft stock 26″ to 63″ wide. This winder operates over a 13:1 ratio — from 3¼″ diam. cores to 43½″ diam. rolls — is limited only by interference on the machine. Of this HYTAC SYSTEM, "Bemis" states — *"Other types of variable speed drives could never do this . . . operating beyond our fondest hopes."*

*HYTAC SYSTEMS — An Oilgear Trademark

NOTE: *An unusual installation feature is partially visible on photo above. Oilgear Type "H" Fluid Power main press drive motor (E) is also direct-coupled to Oilgear Type "H" Pump (F) which supplies Fluid Power to an Oilgear Type "H" Motor — not shown — that drives the dryer fan.*

USER REPORTS — *" . . . exceptionally fine acceleration control . . . smooth creeping and inching speed up to maximum . . . exceptionally smooth running speed . . . are easier to adjust than other drives . . . require less space . . . pressure gage shows load while drive is in operation . . . maintain an adjustable tension from constant tension to constant torque."* "Bemis" — like other users — has found that Oilgear Drive and Control Systems give them constant tension, automatic tapering tension, stall tension, constant torque, automatic tapering torque, or a combination of tension and torque characteristics to meet their every production requirement.

For practical solutions to YOUR linear or rotary Controlled-Motion problem, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

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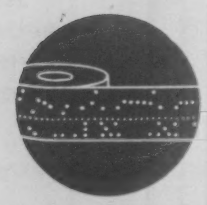
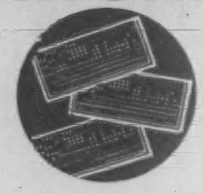


CINCINNATI ACRAMATIC...



complete integration of numerical control and machine design

Here is a simplified numerical control system that brings to more and more shops the cost-saving benefits of this efficient manufacturing concept. This system realizes the full potential of numerical control because all its elements are completely coordinated from their inception under the single responsibility of The Cincinnati Milling Machine Co. . . . where numerical control specialists work hand in hand with machine tool designers, and application and methods engineers.

ACRAMATIC is a simpler, more adaptable system for either positioning or contouring, with a number of practical advantages that reduce the time and cost of both programming and machining . . .

Simplified Contour Programming, requiring less input data because of exclusive parabolic interpolation method.

Cutting Tool Compensation permits change of cutters without change in programming.

Zero Shift Control eliminates need for exact positioning of work on table.

Automatic Repositioning — all dimensions are established from a single base point.

Feed Rate Override allows manual adjustment of feeds below programmed rates.

Accuracy unaffected by varying line voltages, because dimensions are represented by voltage ratios.

There are many other ways in which CINCINNATI ACRAMATIC takes full advantage of the possibilities of numerical control. General information is contained in Publication M-2125, or our Application Engineers will be glad to show you how this unique system can be applied in your shop. May we hear from you?

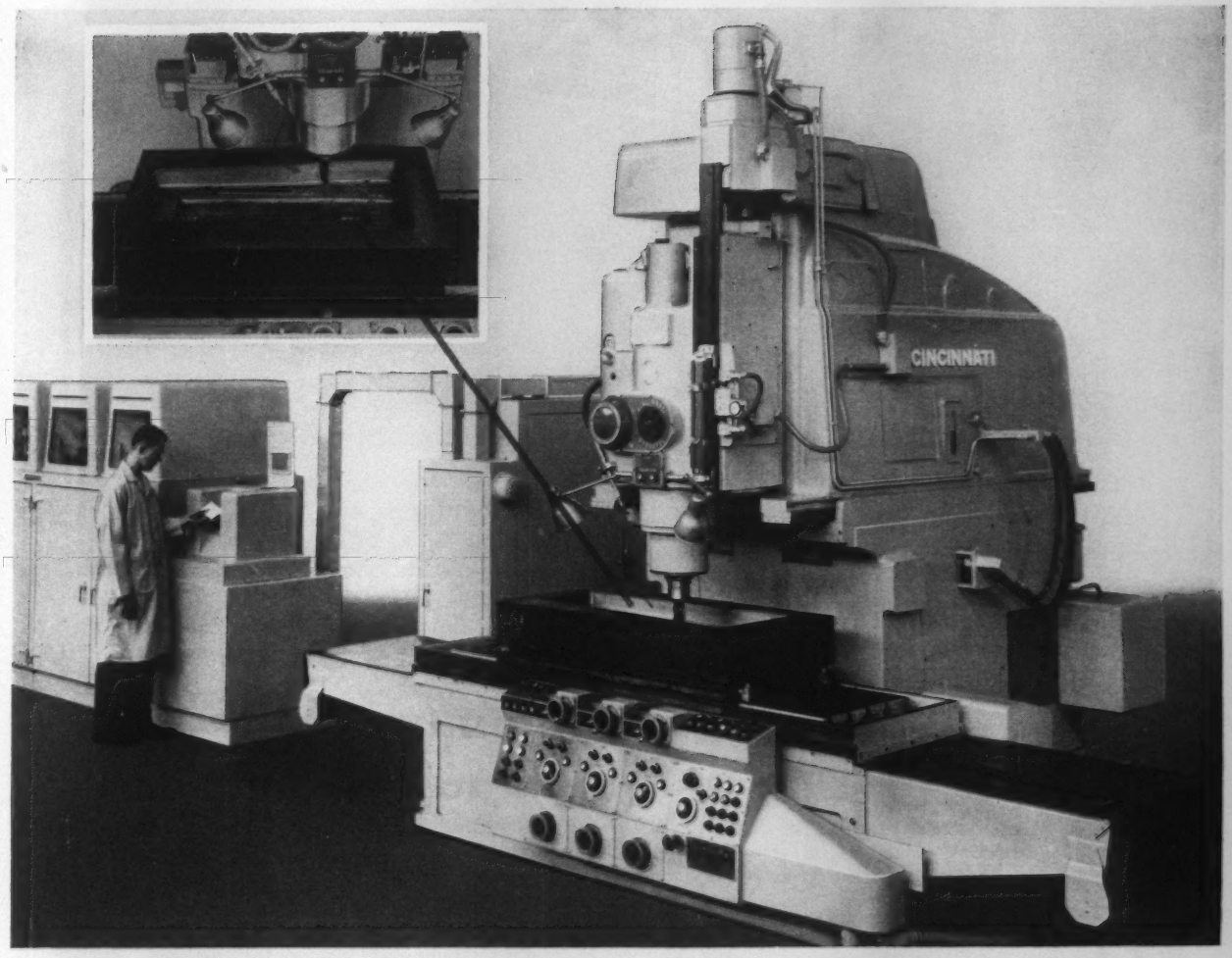
The Cincinnati Milling Machine Co.
Cincinnati 9, Ohio

CINCINNATI

MODERN MACHINE TOOLS — MMT-PE — PRODUCTION EFFICIENCY

Booth No. 1034

BUILDERS OF FINE MACHINE TOOLS: MILLING • GRINDING • BROACHING • ELECTRICAL DISCHARGE MACHINING • DIE SINKING • CUTTER AND TOOL GRINDING • PRODUCTION LINES • METAL FORMING • • HARDENING MACHINES



Above: CINCINNATI 30" x 52" Vertical Hydro-Tel equipped with CINCINNATI ACRAMATIC 3-Axis contour control, performing a die sinking operation on a die for a milling machine motor compartment cover. ACRAMATIC's exclusive parabolic interpolation method programmed this entire complex operation using only 2000 punched cards for the twenty hours of machining required.

At right: CINCINNATI ACRAMATIC 2-Axis Positioning Control automatically provides fast, accurate hole location. Programming requires only the typing of an eight-digit number for each hole location.

CINCINNATI®

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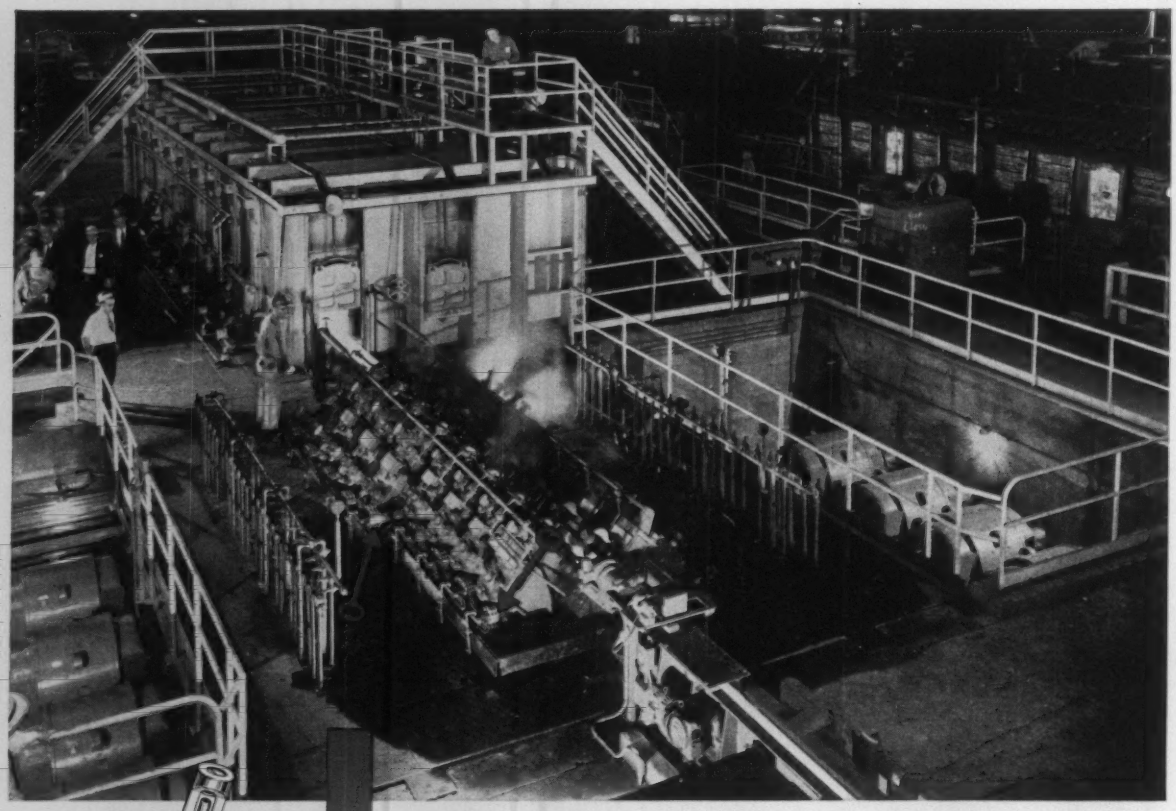
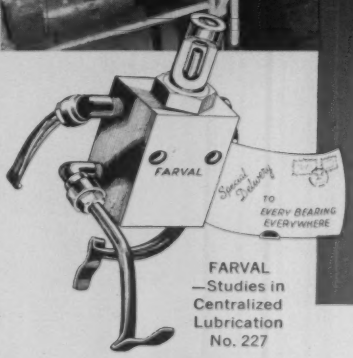




FARVAL
—Studies in
Centralized
Lubrication
No. 227

Farval protects bearings as tubing is reduced from 7 to 2 inches

ON this 16-stand Aetna-Standard tube stretch reducing mill, bearings take tremendous pressures as cherry red tubing is reduced from 7 to 2 inches in diameter. And lubricating those essential components is a Farval centralized system delivering measured amount of lubricant at set intervals to every bearing. These bearings are lubricated automatically and safely while the mill is actually in operation.

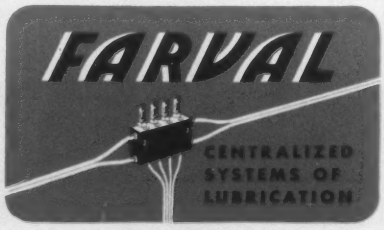
For bearing protection on your machinery, check with Farval for lubrication. For specifications and drawings, ask for Bulletin 26-T. Write

Farval Division • Eaton Manufacturing Company
3265 East 80th Street • Cleveland 4, Ohio

EATON

KEYS TO ADEQUATE LUBRICATION

—wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.



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AUTOMATION news

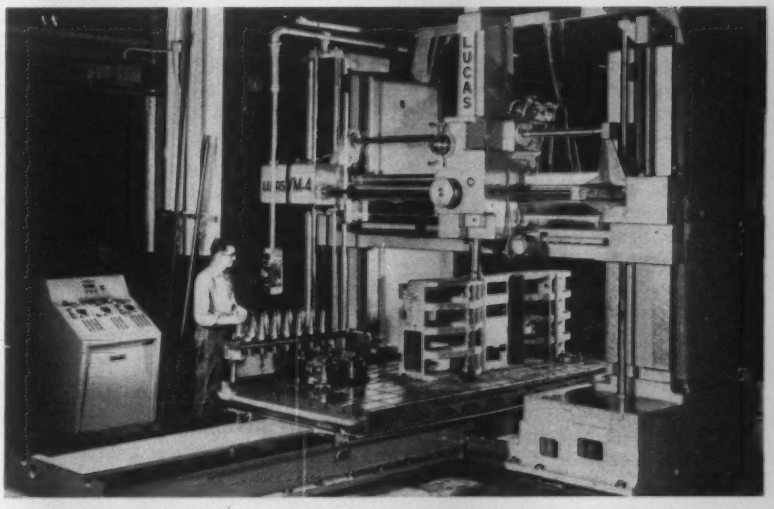
Today's events and developments in the field of automation

Special Machine Features Automatic Tool Changing

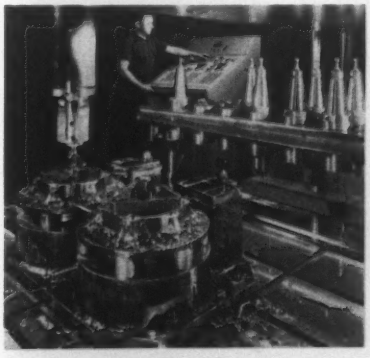
PRODUCT of the growing trend toward automation in metalworking, a special machine developed by the Lucas Machine Div., New Britain Machine Co., was designed specifically to reduce the over-all machining time in medium and small-lot production. The machine, designated Versa-Tronic, is capable of performing milling, drilling, tapping, and boring operations on parts such as large castings.

Mark III numerical controls supplied by the General Electric Co. permit complete program control of positioning for three machine axes, feed rates and spindle speeds, and tool changing of up to 84 tools. Auxiliary functions such as rapid traverse for all motions, and coolant flow, may also be programmed on the unit's 1-inch wide, 8-channel, binary-coded punched tape.

First model of the new machine will be used by the Eimco Corp. to process large cast main frames for earth moving machinery. In commenting on the acquisition, **Leslie S. Seager**, chief production engineer, said: "By selection and purchase of this machine, Eimco Corp. rounded out its requirements in the precision boring, milling, drilling, and tapping operations required for production of our new tractor dozers and front end loaders far more efficiently than we could have by any other means."



COMBINATION vertical boring, drilling, milling, and tapping machine has automatic tool changing feature whereby tools may be changed under program control of punched tape. Positioning of three machine axes, feed rates and spindle speeds, and auxiliary machine functions may also be programmed on tape. Suitable for medium and small-lot production, the unit has a working range 132-inches long, 78-inches wide, and approximately 72-inches high. Tools may range in size from ¼-inch drills to 14-inch diameter face milling cutters.



CLOSE-UP illustrates setup for machining two workpieces clamped in dual fixture. Tool rack in background moves with worktable, and holds tools applicable to a particular job. Under program control, spindle picks up and returns tools in rack.

A feature of the unit is the ability to select any one of eight built-in automatic machine cycles by means of a code in the tape. One such cycle, useful in tapping, causes the spindle to reverse and retract immediately when the programmed depth of tap has been reached. No stopping or tape reading time are involved when this cycle is programmed. Another automatic cycle is used in conjunction with the rapid traverse of a motion to a position where a feed rate is to be used. When the end point of the traverse operation is reached, the traverse rate immediately drops to the programmed feed rate. At this instant, the final point of the cut is read from the tape. Other automatic cycles include control of coarse and exact machining depths with or without dwell when a cutter bottoms on a hole.

Although the normal mode of operation of the machine is by tape control, the unit can also be operated manually or semiautomatically. Manual control is by selection of dials and pushbuttons on a pendant. Semiautomatic control positions the machine to 0.0001-inch in any axis by use of decade pushbuttons on an operator's console. Feeds and speeds in semiautomatic operation are selected manually.

Tools for the machine are stored in a magazine which can be mounted directly on the machine table or attached to its side. To select a tool, its location in the magazine is programmed into the tape in terms of *X-Y* co-ordinates

so that the spindle can locate over the proper point for pickup. Downward motion of the spindle, also tape controlled, fits the tool in place. An orienting control stops the spindle at the correct point to engage the keyway of the tool.

Because of its versatility, the machine is considered suitable for both large and small-lot production. For example, many applications are foreseen in job shops where a variety of machining operations are carried out in unpredictable combinations.

In the words of **Robert Paxton**, president of General Electric Co., "The cost and quality advantages of continuous automatic production are here being coupled with the capability to quickly change production runs. In the light of growing competition for the world's markets, including our own, this kind of flexible capacity is of the utmost importance to manufacturers everywhere. It is insurance that they will lead, not merely meet, competitive demands in the future."

Gages Measure ID and OD Inside Nuclear Reactors

MEASUREMENT of inside and outside diameters of nuclear reactor components, under water and at high temperatures, is accomplished with two special gages developed by Physical Sciences Corp. Because of personnel hazards in this type of work, the instruments have been made remote-reading.

The ID gage is designed to permit a survey of the internal diameter of three-foot long tubes and to measure a variation of plus or minus 0.035-inch from a selected mean diameter. The gaging element, mounted on the end of a 14-foot rod, resembles the machinists' "small hole gage" wherein a tapered center pin is retracted to expand a set of jaws into contact with a hole. The dimension across the jaws is then measured to indicate ID.

In this application, the gage has been equipped with a variable permeance sensor that gives direct readings by measuring the amount of translation of the tapered pin required to cause the jaws to contact the inside of the tube. The output of the sensor is read digitally with separate equipment.

Outside diameter gaging is accomplished with a second type of instrument that senses the separation between a fixed and a movable arm. The movable arm is mounted on pivots so that it remains parallel to the fixed arm over the entire measurement range. A variable permeance sensor measures the spread between the arms when they are clamped to the outside of fuel rods, structural members, etc., in the reactor. Variations of plus or minus 0.035-inch can be measured, and dimensions are indicated remotely on digital equipment.

MODERN MACHINE TOOLS
MMT=PE
PRODUCTION EFFICIENCY

PLAN NOW to attend The Machine Tool Exposition — 1960, to be held at the International Amphitheatre in Chicago next month, Sept. 6-16. For reasons why you can't afford to miss this event, see page 13. The Exposition, and concurrent Production Engineering Show at the Navy Pier in Chicago, will offer an unprecedented opportunity for updating your knowledge of what's new on the production equipment scene for *your* industry.

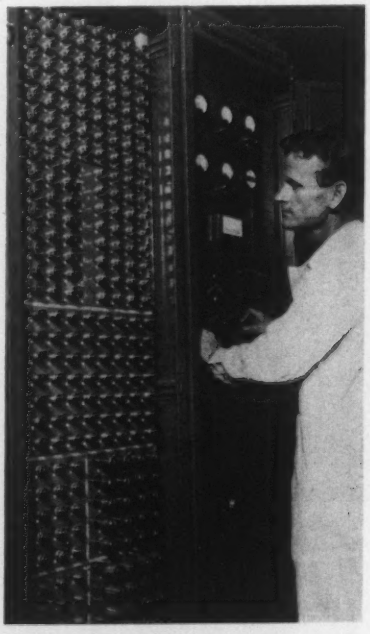
Instrument Maker Announces Equipment Leasing Plan

ARRANGEMENTS for instrument users to lease devices such as process control analyzers have been completed with a national leasing firm by the Instrument Div., Perkin-Elmer Corp. The Instrument Div. is a producer of analytical instruments for product quality control, plant process control, and research.

The leasing plan has been arranged with the Horton Equipment Leasing Div. of Advance Industries Inc. Under the plan, instrument users may lease Perkin-Elmer instruments at a nominal monthly rate for each thousand dollars of the equipment's purchase price. At the end of an initial three-year rental period the user may renew the lease or purchase the instrument at a small percentage of its original cost.

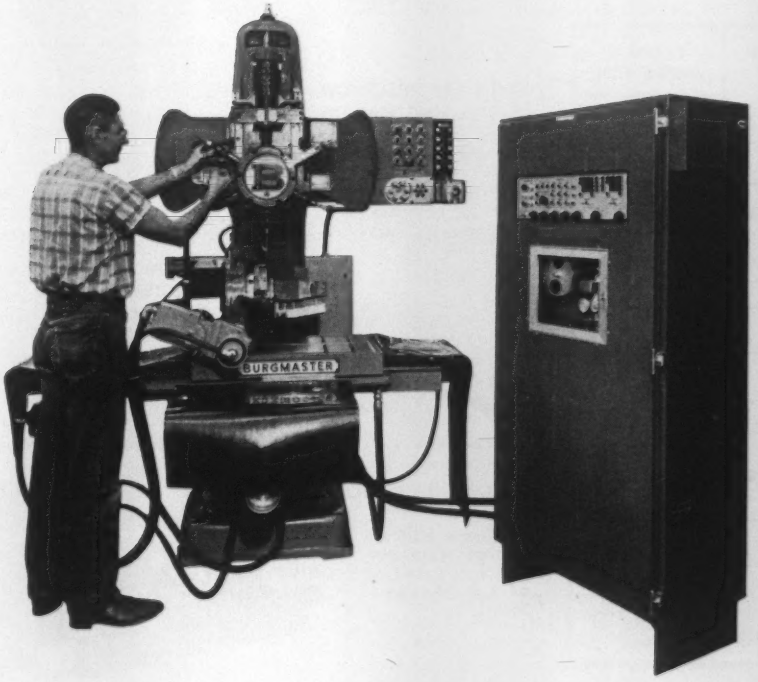
When a lease has been executed,

SAVINGS in both numerically controlled machine downtime and purchase of electronic tubes are being realized at the Wichita, Kans., Div. of Boeing Airplane Co. through use of this tube aging bank. Experience revealed that much of the machine downtime was due to failure of electronic tubes during their first 300 to 400 hours of operation. The bank was designed and built by Boeing to age new tubes before they are installed in the machine controls. In the bank, which holds approximately 300 tubes, each unit is subjected to simulated operating conditions for periods ranging from 200 to 400 hours. Tubes that fail during the aging process (from three to five per cent of those tested) are returned to vendors for replacement. Those that pass the aging test are placed in use and have life expectancies between 5000 and 10,000 hours, depending upon the type of tube and circuit application. Boeing officials estimate that use of the device has helped reduce downtime of numerically controlled machines, due to tube failures, by 40 to 50 per cent. Another advantage claimed for the aging process is that tubes become more stable as a result of the test. New tubes have a greater tendency to be erratic and give inconsistent performance, according to Boeing.



lead time cut over 50%— $3,000 saved on tooling with Hughes Tape Controlled Burgmaster

PROBLEM: To drill, countersink and tap 69 holes, including radial locations, to close tolerance in 50 missile bulkheads.



SOLUTION: Hughes All-Electronic Numerical Controls, a precision Rotary Table, the Burgmaster Turret Drill with two-axis positioning table, and existing simple fixtures and clamps. The need for complex multi-base drill jigs and other expensive tooling was eliminated.

RESULT: Hughes Tape Controlled Burgmaster saved over $3,000.00 in tool design and manufacturing time. Lead time was reduced by five weeks.

Hughes All-Electronic Numerical Controls are completely transistorized—and are immediately available for use on new machines or for retrofit of older units. These controls are now offered as standard equipment with Burgmaster Turret Drilling Machines.

For more information on how you can increase your profits with a Hughes Tape Controlled Burgmaster, contact your local Burgmaster Representative. Or, write:

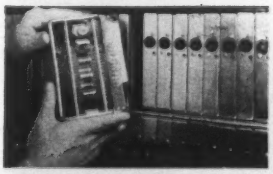
HUGHES Industrial Systems Division, P.O. Box 90904, International Airport Station, Los Angeles 45, California.

For export information, write: HUGHES International, Culver City, California.

Creating a new world with ELECTRONICS

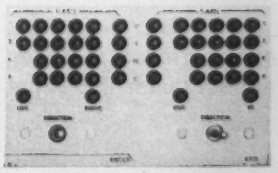
HUGHES

INDUSTRIAL SYSTEMS DIVISION
HUGHES AIRCRAFT COMPANY



Trouble-free operation; easy electrical maintenance: Transistorized circuitry and modularized construction assures you uninterrupted production with low power consumption; simple replacement and repair. *No service contract needed!*

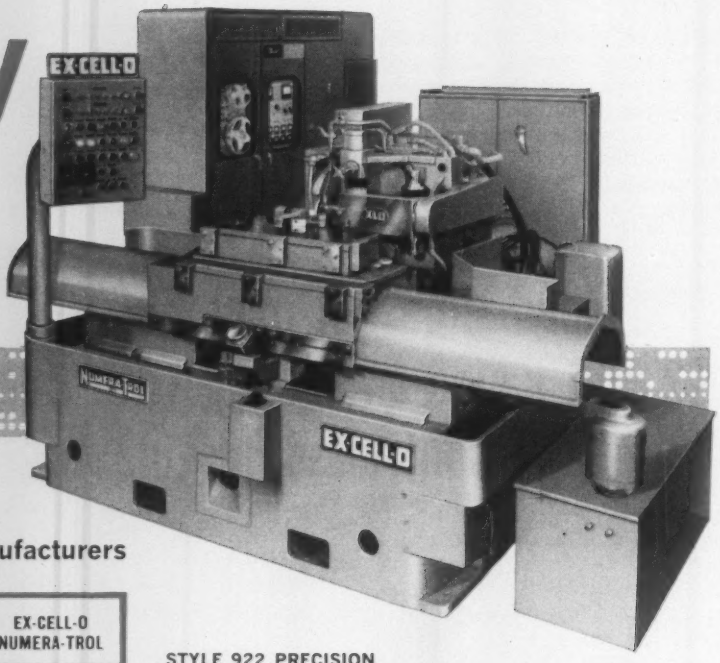
Longer tape life with extra accuracy: Sensitive photo-electric tape reader eliminates deformation of tape holes; reduces possibility of tape wear and tearing. No pneumatic or hydraulic connections required for tape reading operation.



Easier set-up and program checking: Display lights on control panel indicate coordinate dimensions enabling operator to verify the accuracy of programming quickly and easily. Control panel human-engineered for maximum efficiency in operation.

Fast, accurate positioning; easy mechanical maintenance: Drive package positions table at 180 inches per minute; repeatable accuracy: ±0.0002", non-cumulative. Use of standard industrial electric motors and clutches assures quick repairs.

a study in time



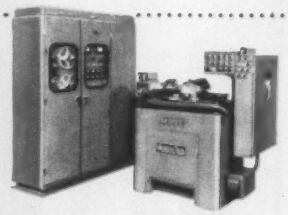
How Ex-Cell-O Numera-Trol Cuts Costs for Three Modern Manufacturers

Part: TEMPLETS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	128 hrs.	16 hrs.
Grinding per/piece	60 hrs.	6 hrs.
TIME SAVED	166 HOURS	

Part: FUEL CONTROL CAMS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	150 hrs.	40 hrs.
Machining per/piece	80 hrs.	7.5 hrs.
TIME SAVED	182.5 HOURS	

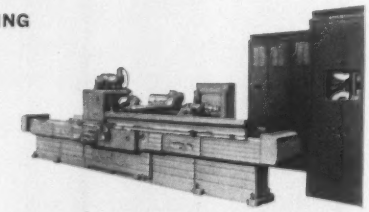
Part: STEAM TURBINE BUCKETS	CONVENTIONAL METHODS	EX-CELL-O NUMERA-TROL
Lead time	144 hrs.	24 hrs.
Machining per/piece	90 hrs.	12 hrs.
TIME SAVED	198 HOURS	

STYLE 922 PRECISION CONTOURING MACHINE
Slides are controllable to .000025". Grinding unit is interchangeable with boring and turning unit.



PRECISION CAM-MILLING MACHINE
Slashes lead time in producing drum-type cams.

PRECISION PROFILING MACHINE
Performs intricate and accurate milling and grinding of 3-dimensional forms.



Are you faced with tough prototypes or production parts that "can't" be produced economically? See your Ex-Cell-O Representative, or write direct for details on how you can apply Ex-Cell-O's Numera-Trol system of tape-controlled precision machine tools to do more jobs, faster and more accurately!

FREE—"A Guidebook to Numerically Controlled Machine Tools." Send for your copy today.

NUMERA-TROL (XLO)

60-44

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Machinery Division

EX-CELL-O CORPORATION
DETROIT 32, MICHIGAN

SEE EX-CELL-O'S BOOTH 946, NMTBA EXPOSITION

Circle 660 on Page 19

Horton purchases instruments specified by the user from Perkin-Elmer, and directs shipments to the users' plant.

According to **Horace G. McDonell**, sales manager of the Instrument Div., the leasing arrangement will make it possible for both large and small companies to pay for new instruments from current cost savings. The plan also eliminates a capital expenditure for the user, and becomes a regular operating expense on a month-to-month basis.

Joint Ownership Planned For Electronics Firm

AGREEMENT on joint ownership of a west coast electronic systems engineering firm has been announced by Allis-Chalmers Mfg. Co. and Bell & Howell Co. According to the agreement, Allis-Chalmers will acquire 50 per cent of the common stock of Consolidated Systems Corp., a wholly owned subsidiary of Bell & Howell's Consolidated Electrodynamics Corp. The joint ownership venture will integrate Allis-Chalmers' capabilities as a major manufacturer of heavy industrial equipment with the technical resources of a firm which is experienced in applying the "systems engineering" concept.

In announcing the move, **R. S. Stevenson**, president of Allis-Chalmers said: "In recent years application of electronic instrumentation to industrial processes, including power generation, has increased tremendously. Many of our customers are now looking for us to provide them not only with industrial equipment, but also the systems control necessary to automate their processes.

"Consolidated Systems Corp., which has designed and constructed hundreds of custom-engineered systems for scientific, military, and industrial use, within the past six years, will provide important new service to Allis-Chalmers equipment users."

According to **C. H. Percy**, president of Bell & Howell, a major objective of Consolidated Electrodynamics Corp. "is to increase its share of the industrial control instrument market. The Allis-Chalmers/Consolidated Systems combination will provide an opportunity for major progress."

AUTOMATION NEWS FEATURE

Significance Of The Machine Tool Exposition—1960

IN THIS special report, a leading industrialist points to national and international trends that will soon compel the rapid upgrading and modernization of U. S. productive facilities in all fields. The significance of The Machine Tool Exposition—1960 in light of these worldwide forces is ably brought out by the author, who is president of the National Machine Tool Builders' Association.

By ALAN C. MATTISON
President
Mattison Machine Works
Rockford, Ill.

TO UNDERSTAND what The Machine Tool Exposition—1960 means, it is necessary to review the over-all situation in this country, both with respect to machine tools and with respect to products made by machine tools—with emphasis on machine tools.

Let's consider the whole broad business picture. The fact is that we are now doing business in the United States in a climate that is for the most part new to American industry. Competition has gone international. Imports have been going up, and exports have been going down. Unless something is done to reverse this trend, the country is in for serious trouble. All of our thinking and planning has to be done in light of that situation. Throughout our economy, we have been advancing wages and prices, apparently on the assumption that we could keep on doing that forever. Well, the day of reckoning is at hand.

We have raised price levels of all sorts of produce to such a point that foreign competition can invade our own domestic markets. Now you can excuse it, any way you please. You can say that the tax burden has added to costs. You can say that wage increases necessitated higher prices. But that doesn't alter the situation. The hard fact is that as a nation we are pricing ourselves out of our markets.

Foreign wage rates remain far lower than ours. And production methods and equipment in many other countries are today comparable to ours. In fact, in West Germany, plant equipment is, on the average, newer and better than in the United States.

After World War II, we helped get various foreign nations back on their feet. Well, they got back all right. They forged right ahead. There is an amazing industrial resurgence throughout Europe. So-called underdeveloped countries such as India are industrializing. Japan is pushing ahead. And, behind and beyond all these is the unknown production potential of Russia and other Communist nations.

All of these countries are looking hungrily at U. S. markets. As things stand today, makers of many items can pay our tariff and still undersell domestic manufacturers here in the United States. And they are doing it. Many industries have already been seriously affected: Watches, textiles, bicycles, and sewing machines—I could go on and on. The machine tool industry is no exception; machine tool imports into this country in 1959 were, in dollar volume, 95 per cent above those for 1955.

Now let's think about the industries that use machine tools we build. Every day they face the growing threat of the invasion of their domestic markets by foreign products. What are they going to do about it?

It's all very well to stir up patriotic sentiment about products made in America—but when the chips are down, people will buy where they can get the most for their money. They are not going to pay more for a product than they need to pay.

A market cannot be sustained by what might be called marginal considerations. For example: American automobile manufacturers appealed to the people on grounds of beauty of design, comfort, and social prestige—but along came European builders and offered *cheaper* transportation. European competition is causing a revolution in the U. S. automobile industry.

People talk about tariffs. But as of today, can you imagine our Congress reversing our foreign trade policy and going all out for higher tariffs? Besides, tariffs in many cases would not be enough; the price differential is too great.

The only way for manufacturers to meet foreign competition in United States markets is to get their costs down to where they can offer competitive values. But *how* are they going to get costs down? Is there any prospect of lower taxes? Is there any prospect of lower wages? Is there any prospect of lower material costs?

There's only one way, as I see it, open to the businesses of this country, right now, to cut costs in order to meet the growing threat of competition of the lower priced imports. And that way is to modernize plant and equipment. That is why The Machine Tool Exposition—1960 is of such significance.

The fact is that the inroads of foreign competition may at long last serve to correct two economic fallacies under which we have been laboring in the United States.

The first of these fallacies is that high-

What a memory! How do you check quality and record it on coils of tinplate up to three miles long? New Cutler-Hammer sensing, memory device does it. It's the first of its kind anywhere.

What a view! Here's a radar picture of all runways at Idlewild Airport. It's so clear you could identify a horse two miles away! Another Cutler-Hammer development.

What's new in control for automation?

An automatic warehouse that tells car bodies when to stop and go

Cutler-Hammer system directs car bodies to and from storage area for a major automobile manufacturer. The need was for a buffer storage area for car bodies between the assembly plant and the body building plant.

Before this storage area idea was conceived, car bodies went from the line of the body plant right to the line of the assembly plant. If one line had to shut down, the other did, too.

Cutler-Hammer systems control men developed the electrical control that sorts the car bodies coming from the body plant to one of eleven storage conveyors. Also, any body style can be taken off the conveyor and sent to the assembly line.

And, now? No shutdowns in one plant if the other is shut down temporarily. Any body style needed can be put on the assembly line. Couldn't be done before. So now, parts shortages affecting one body style don't affect production.

The conveyor system installed only last year is paying big dividends in reduced assembly line costs. As a result, several similar installations have been ordered.

The importance of an electrical control man. A Cutler-Hammer control man can bring wide experience to your automation planning table. He's handled many different products. He's worked with many different systems. With the proper control recommendations, many thousands of dollars can be saved.

The big change at Cutler-Hammer. You can see a change at Cutler-Hammer. We've prepared for the expected growth in the sixties with new, better products, new plant capacities, new engineering talent. If you're planning ahead, we'd like to talk to you. We could save you time and money in your automation planning. Contact the Cutler-Hammer sales office nearest you to see how.

Automation is more efficient when the control expert is called in early.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

Circle 661 on Page 19

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HOUSTON, TEX. Capitol 5-0356
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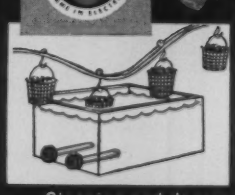
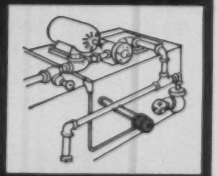


Cleaning and degreasing solutions.

Quenching oil.



Forced-pressure lubricating systems.

EDWIN L. WIEGAND COMPANY
7500 Thomas Boulevard • Pittsburgh 8, Pa.
CHurchill 2-6400

er wages increase purchasing power and raise the standard of living. The simple economic fact is that wages are an element of cost. Higher wages mean higher costs. Higher costs mean higher prices. The result is not an increase in real purchasing power; the result is inflation.

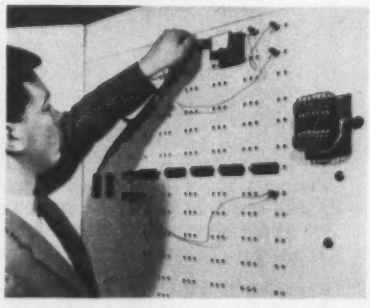
The second fallacy is that increases in productivity have been due to labor. I don't need to emphasize that increases in productivity, in recent years at least, have been due almost entirely to advances in technology—to the development of machines and equipment that mean greater output per man per hour.

The remedy for the dilemma that we're in is clear. I can state it in a single sentence. It is just this: *Stabilize costs and transform technology into lower prices.* In short—become competitive again.

That is the vitally important thing that we will demonstrate at The Machine Tool Exposition—1960. It isn't necessary for American metalworking manufacturers to accept foreign competition as an unbeatable proposition. When metalworking executives see the possibilities of the machines that will be exhibited in Chicago they will realize that with those machines, plus anti-inflation management policies, they can regain control over costs, they can reduce costs, they can once again be able to offer better things to more people at lower prices.

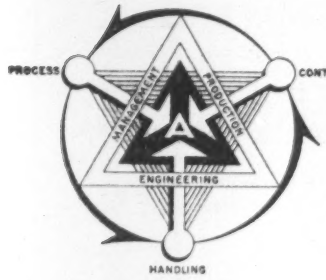
That's why I say that The Machine Tool Exposition—1960 may well touch off a sweeping program of modernization. It seems to me that this is inherent in the very nature of the situation. If the American metalworking industry is to maintain its position, it *must* modernize.

Now let's consider the situation of our own particular industry within the overall picture. We ourselves are a part of the metalworking industry, and the same



STATIC control simulator designed by the engineering staff of Control Div., Magnetics Inc., can be programmed to display a variety of conventional single phase magnetic amplifier circuits. Connection of switching reactors, meters, resistors, diodes, and capacitors into circuits is accomplished with a system of plugs and jacks. A servomotor, industrial contactor, and a solenoid mounted on the panel may be driven by the switching reactor.

Circle 662 on Page 19



around the triangle

THERMOCOUPLES FOR HOT PLACES

Two new types of thermocouples being marketed by Brown Instruments Div., Minneapolis-Honeywell Regulator Co., are said to operate with outstanding stability in high temperature measurements. One type, which uses iridium and rhodium-iridium elements, promises to be useful in vacuum, oxidizing, and inert atmospheres at temperatures up to 3600F. The second type employs tungsten and rhenium elements, and is usable in atmospheres other than oxidizing at temperatures up to 4000F. Investigations leading to establishment of new values for the thermocouple materials were carried out by Honeywell in co-operation with the National Bureau of Standards and with other companies.

DIGITAL INPUTS CONVERTED TO ANALOG POSITIONING SIGNALS

An electronic device developed by Norden Div., United Aircraft Corp., performs continuous digital comparison of command and feedback signals and produces an analog drive signal for positioning applications. Called Comparatron, the unit has found extensive use in the company's point-to-point numerical control systems. Two models are available, depending upon the form of input. One model accepts up to two 24-bit parallel binary numbers, and the other model operates with up to two 24-bit parallel binary-coded decimal digits. Input data may be derived from storage registers, handset switches, or shaft encoders. Output is a 60-1000 cps, error-modulated ac voltage.

DO-IT-YOURSELF MOLD MATERIAL CURES WITHOUT HEAT

A liquid silicone rubber formulation, designated RTV because of its room temperature vulcanizing properties, has been developed by the Silicone Products Dept. of General Electric Co. Features of the material include high temperature resistance (to 600 F), low shrinkage (less than 0.2 per cent), and easy release to prevent sticking of parts. Application may be by dipping, pouring, or pressure gun. Industrial uses for the material include flexible molds and assembly fixtures. In one instance, a conveyorized fixture used for assembling motor switch components was precision cast in two pieces from a master pattern at a savings of more than $150 per fixture over a previous design. Other uses for the material include coating of tanks, metal conveyors, conveyor hooks, and ducts, and as a patching compound for repairing silicone rubber belts and seals. It can also be used as a potting, impregnating, and encapsulating material for electrical components.

CASEY JONES NEEDED THIS AID

Facilitating train movements over single track lines is a task for digital computers, according to three General Railway Signal Co. engineers. Speaking at a recent meeting of the American Institute of Electrical Engineers, they said: "A digital computer program has been designed to aid railroad management in selecting the proper siding locations and signal spacing when considering a centralized traffic control system. Using an IBM 650 computer the traffic pattern of up to 10 trains operating at one time on a 100 to 150 mile division of a railroad can be predicted. The initial information stored in the computer memory describes the grades, curves, speed restrictions, signal locations, and track layout of the railroad. Also, data for each train are available to the computer. This information includes the number, weight, and type of cars, the power of the locomotive, the origin and destination, and the time of departure." Improved signal systems such as centralized traffic control have enabled railroads to move traffic on a single mainline track, with passing sidings, in place of two or more tracks, they explained.

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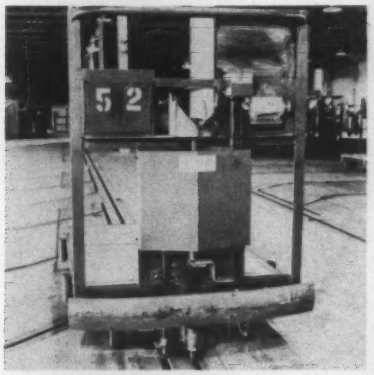


TOWLINE cart developed by S. I. Handling Systems Inc. is equipped with mechanical memory and switching mechanism that permits routing of cart off a main towline and onto a preselected spur line. Dispatching is accomplished by setting a predetermining counter to desired spur station number. When distance has been paced off by the counter, the cart is automatically disengaged from the main towline and a pin enters a slot in the selected spur line.

factors apply to us as to the metalworking industry as a whole. There is, however, a special consideration in our case; namely, the relationship of machine tools to national defense.

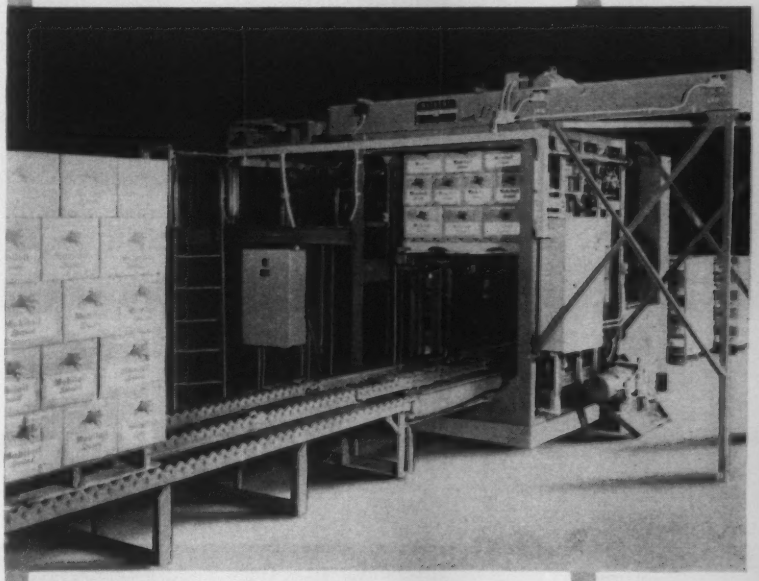
Based upon that premise our industry has given our government facts and figures with respect to the machine tool Export and Import situation. We have explained how low production costs abroad, due to low wages, make it necessary for American machine tool companies to set up machine tool facilities abroad if we are to compete in foreign markets. We have given government the facts as to the impact of foreign competition upon our domestic markets.

We have made clear the adverse effects which these factors have upon maintaining within the United States a machine tool capacity adequate for national defense. Thus far all that I can report is that the government has the matter under consideration—it is interested but not sufficiently concerned to take action.

We have also explained to government the unfortunate effects of the Buy American Act, as it applies to machine tool purchases by the Defense Department. Meanwhile, we have continued to impress upon the Treasury Department and the Congress the need for revision of present depreciation policies, and I think we have been making headway in that direction. But the wheels of government turn very slowly. Eventually we may get some action. But meanwhile we are faced with an immediate situation. We can't just sit still and wait for government.

As I see it, making arrangements for production facilities abroad is forced upon us by today's circumstances. In this way

for outstanding performance put MATHEWS METHODS into your mechanized handling program



This machine is one of a complete line of Mathews Automatic and Semi-Automatic Pallet Loaders.

• Whatever your conveying problem might be—if it involves package handling—Mathews will build the equipment to do the job best for you.

You'll get a complete conveyer service, from proposal engineering through installation, and equipment that will deliver outstanding performance.

That is why we believe you get the most for your money when you buy Mathews Conveyers.

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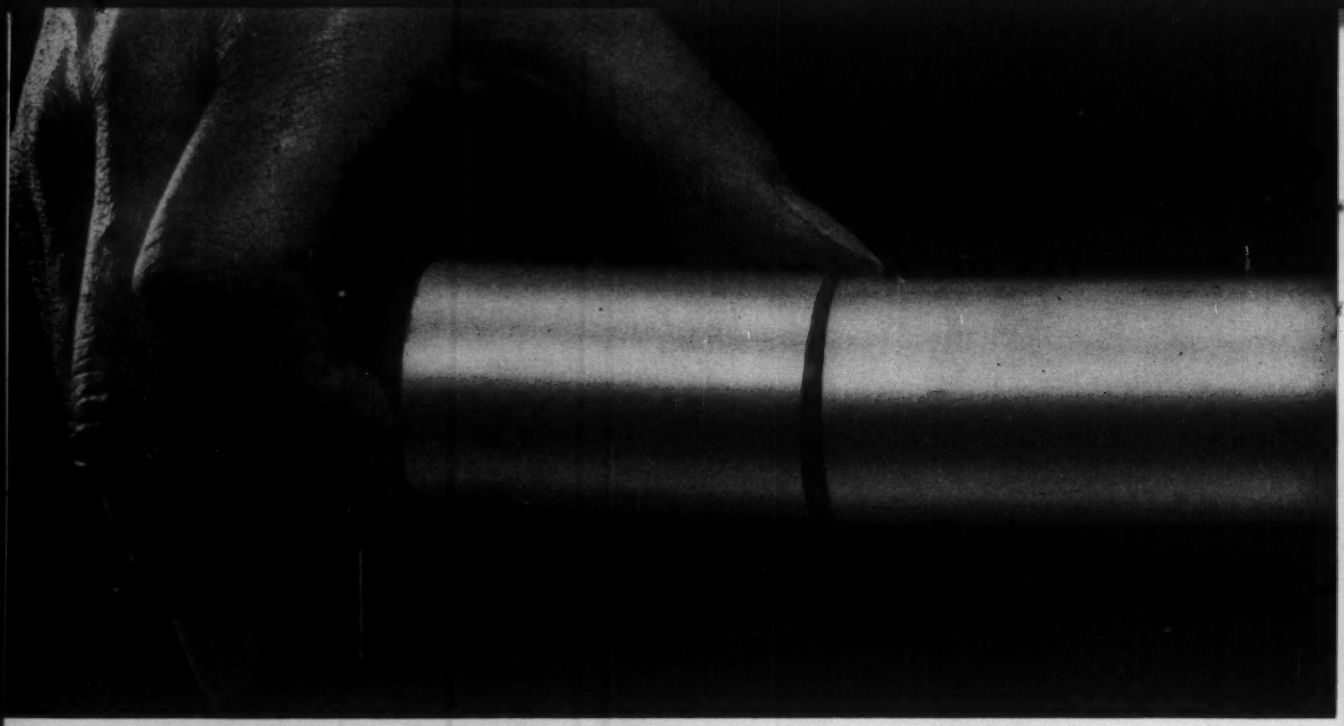
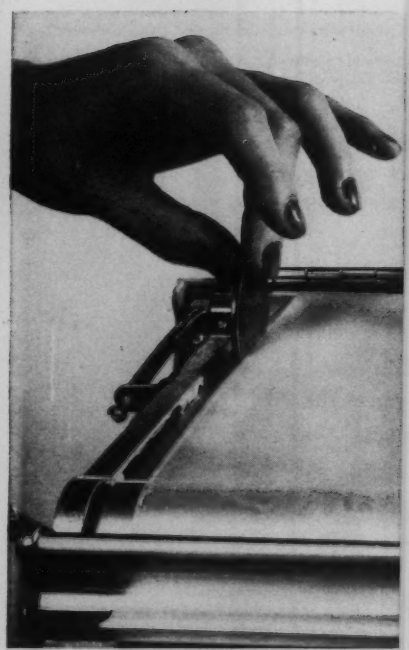
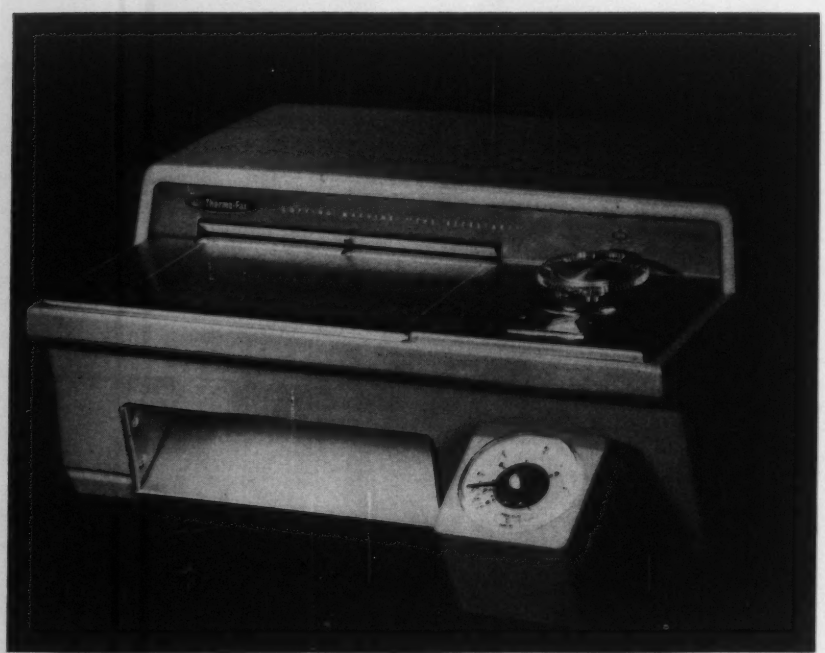
Circle 663 on Page 19



Belt alignment assured in



Thickness of a silver dollar indicates the close tracking tolerance of the belt which is 24 inches in circumference.



Thermo-Fax COPYING MACHINES

3M BRAND

The THERMO-FAX "Secretary" Copying Machine, built by Minnesota Mining & Manufacturing Company using LORIG-ALIGNER Self-Centering Rolls. The terms "Thermo-Fax" and "Secretary" are registered trademarks of the 3M Company, St. Paul 6, Minnesota.

The tilting end sections of the LORIG-ALIGNER roll exert a strong self-centering action that keeps belt in alignment.

"Thermo-Fax" Copying Machines
BRAND

designed with Lorig-Aligner Self-Centering Rolls

This THERMO-FAX "Secretary" Copying Machine has a plastic belt, 24 inches in circumference and 9⅜ inches wide, that must travel in almost perfect alignment for the optimum in reproduction. Early models used complicated tracking mechanisms, including motors and limit switches.

Then by using LORIG-ALIGNER Self-Centering Rolls, designers produced a simplified machine, eliminating a number of costly parts. The belt stays in alignment, sizable savings in manufacturing costs are realized, and greater reliability of service is obtained.

This mark tells you a product is made of modern, dependable Steel.

Where LORIG-ALIGNER Self-Centering Rolls can be used to obtain greater production. On metal strip processing lines, conveyor systems, grinding machines with belts, textile machines, paper-making machines, in fact, any place involving the alignment of a belt or web. Just send the coupon for the complete story.

USS and LORIG-ALIGNER are registered trademarks of United States Steel

United States Steel
Room 2801, 525 William Penn Place
Pittsburgh 30, Pa.

Please send your booklet, "LORIG-ALIGNER Self-Centering Rolls" to:

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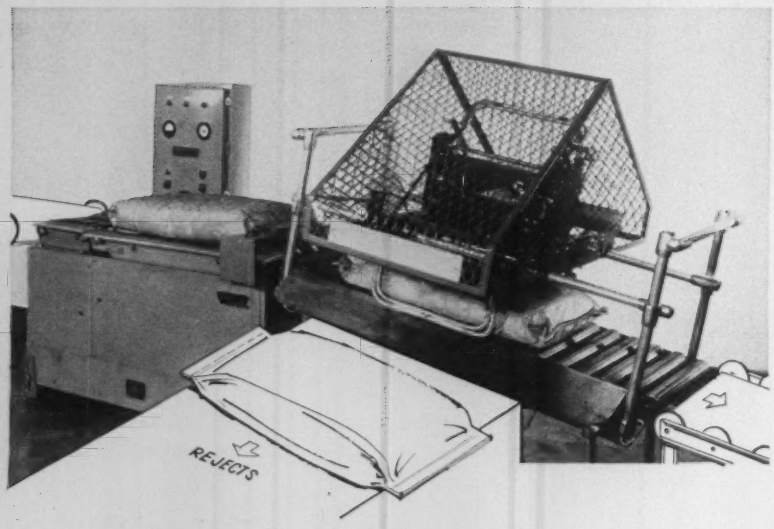

SELECTROL® checkweighs bags with 1/10 of 1% accuracy

...with rate of speed at twenty 50-pound bags per minute...

Model 1250 Selectrol, designed for installation in a production line, checkweighs bags from 25 to 150 pounds in motion... and detects weight variations as small as 1½ ounces or less per 100 pounds. Speed is variable — up to 25 bags per minute, depending on size and weight. Tolerance is adjustable to your requirements.

The Selectrol shown above has automatic overweight and underweight rejection mechanism. Models are available with underweight rejection only or without rejection mechanism. All electrical parts are fully protected against dust and oil.

Optional equipment includes: recorders, counters, visual and audible signaling devices and special control accessories to your requirements.

Selectrols are made by Exact Weight, a leading manufacturer of job-engineered scales for 45 years with experience gained through hundreds of checkweighing installations.

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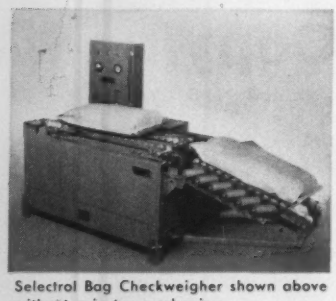
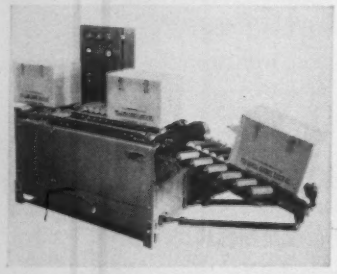


Selectrol Bag Checkweigher shown above without rejector mechanism



Selectrol Case and Carton Checkweigher with rejector mechanism. Acceptable weights continue in a straight line; over and under weight cartons are diverted off the line.

Exact Weight SCALES

THE EXACT WEIGHT SCALE CO.
907 W. FIFTH AVE., COLUMBUS 8, OHIO
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Circle 664 on Page 19

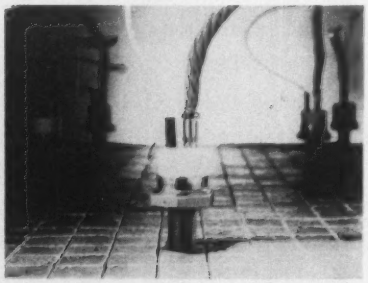
we can sell machine tools which we could not sell if they were produced in the United States, because of the wage and price differential. Here at home I think we must take our own medicine. We should be the very first to modernize, to regain a firm control over costs, and to endeavor to transform technology into better values for the customer.

But our best method, and the traditional method, of meeting the threat of foreign imports is that of out-designing our foreign competitors. That is our great strong point. That, I think, we are definitely doing—as will be proved by the machines on exhibit in Chicago. Demonstrating the superiority of American machine tool design will be one of the most important uses of The Machine Tool Exposition—1960.

Precision Boring Machines Have Numerical Depth Control

NUMERICAL depth control is now available as an option for precision boring machines manufactured by Fosdick Machine Tool Co., according to a recent announcement. The control can be added to Fosmatics that have 2-axis table positioning controls to create versatile, 3-axis machines. With depth control, such machines are especially suited for small-lot boring operations requiring accuracies to plus or minus 0.0001-inch.

Elements added to the basic numercial control system to accomplish depth control include a depth memory employing a telephone-type mechanical crossbar switch and latching relays, a visual read-

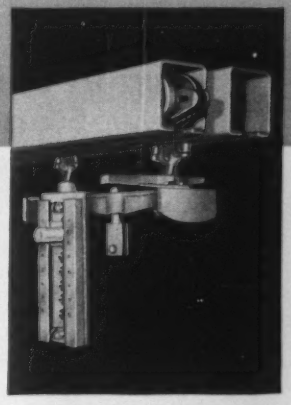


SEMICONDUCTOR switching device, called a Trinistor controlled rectifier, has been developed by Westinghouse Electric Corp. Characteristics of the device are similar to those of a thyratron, in that the unit will block voltage in one direction below a critical breakover voltage. However, by exceeding the critical breakover voltage, or applying a proper gate signal, the device will rapidly switch to its conducting state. The units are best suited for high power applications employing up to 300 volts and up to 50 amperes.

"A major cost-reduction must come from costs other than direct labor and material costs! Management must pin-point actual materials handling costs"

You can best reduce manufacturing costs with...

R-W "TWIN-TRAK"
OVERHEAD AUTOMATIC DISPATCH SYSTEMS



An R-W "TWIN-TRAK" Overhead Automatic Dispatch System consists of one or more Power Tracks and as many Storage or Load Tracks as desired plus Switches, Carriers, Accessories and Power Equipment. "TWIN-TRAK" Systems are economical to install, operate and maintain . . . easily expanded, altered or relocated as necessary.

Industry's prime goal throughout the '60's will be to achieve substantial manufacturing cost-reductions. The handling of materials offers the greatest cost-cutting frontier and reduced costs will be accomplished only with a true "integrated" materials handling system . . . a system that co-ordinates all processing functions on a *door to door* or *plant wide basis.*

R-W "TWIN-TRAK" Systems offer this materials handling concept of tomorrow—*today*. For here is a completely automatic conveying system that not only moves products from one point to another, but automatically conveys parts and components to predetermined work stations throughout all production processes . . . parts and components that are automatically selected "from overhead" inventory banks and conveyed *where* they are needed—*when* they are needed. R-W "TWIN-TRAK" Systems not only improve materials handling but also permit the co-ordinated use of new production techniques and machinery to provide "machine muscle" for the raising, lowering, moving and transferring of parts and components to produce products faster and more economically. Now is the time to investigate the "cost-saving" potential offered by an R-W "TWIN-TRAK" Overhead Automatic Dispatch System.

If you are planning to modernize your present plant or build a new one, it will be to your advantage to let a qualified R-W Materials Handling Speciglist survey your facilities or plans. At no obligation, he will gladly submit a plan to show you how to best solve your specific materials handling problem. Write for "TWIN-TRAK" Catalog.

R W

Richards-Wilcox

MANUFACTURING COMPANY

MATERIALS HANDLING DIVISION

417 W. THIRD ST., AURORA, ILL. Branches in all Principal C ties

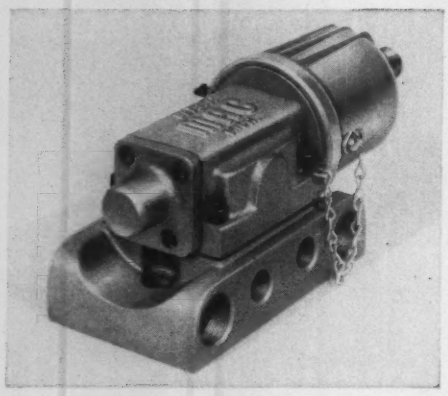
Circle 665 on Page 19

New Solenoid Air Valves Need No Accessories

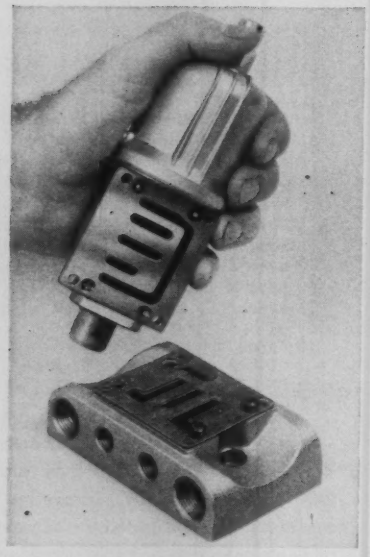
Now available for the first time are solenoid operated air valves complete with all accessories at 'bare valve' prices. Available in ¼, ⅜, and ¾ in. port sizes, they come in single- and double-solenoid types in 3-way, 4-way and 4-way 5-port models.

Features include: solenoids interchangeable on all models of a given size; pre-wired plug-in type bases, eliminating customary wiring; standardization of bodies and bases for interchangeability; unusual compactness; elimination of troublesome fasteners in solenoid assembly (which floats in rubber).

All valves are equipped with screwdriver or ball type manual solenoid operators with lock-in and lock-out feature.



Manifold type bases with common inlet exhaust, and conduit, available on ¼ in. models. For complete information, ask for MAC catalog #60.



Plug-in Connectors Now Standard on All MAC Solenoid Valves

Pre-wired bases, into which you simply plug in the valve body, are now standard on all MAC solenoid valves—both direct-solenoid and solenoid-air types. Bases are identical for single- and double-solenoid valves of a given size.

The same principle is also applied to the "add-a-unit" manifold type bases available for all MAC solenoid valves. With these, from 2 to 10 valves can be coupled with common inlet, exhaust and conduit. Individual valves can also be isolated or pressure fed in from each end.

With plug-in leads provided on all solenoids, wiring of valves has been reduced to the utmost in simplicity.

NEW!

Write today for this free air-valve manual and catalog.

You'll be surprised at how much time it will save you in picking just the right valve for your application. Ask for Catalog #60.

advances in
PNEUMATICS

MAC

evolution of valve seals...

While metal-to-metal seals work well in hydraulic valves, where inherent leakage is accepted, positive leakproof sealing is mandatory in air valves. Flexible seals are today accepted as vital and they must be so designed that sealing efficiency increases with pressure. The seal should be self-cleaning so that foreign matter won't cause leakage.

At one time O-rings were thought to be the answer. O-rings are excellent for static sealing or where travel is short. O-rings are unsatisfactory, however, when used as valve seals crossing an orifice due to the shearing action.

Developing the best design and compound for air-valve seals was a long and tedious job, since elasticity, durometer hardness, compression set, and co-efficient of friction are also important factors.

Experience to date has proven that the best valve seal is a special Buna-N base self-lubricating oil-resistant compound—bonded to the metal to keep it from distorting.

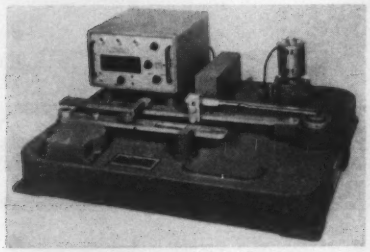
This is the type of seal used in MAC valves. We believe it represents an ideal combination. At least, their amazingly long life in MAC valves seems to confirm that belief.

President

MAC

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park • Detroit 37, Michigan

Circle 666 on Page 19



AUTOMATIC calibrator which loads and reads out actual "break-away" values of torque wrenches has been developed by Steel City Testing Machines Inc. In operation, a wrench is inserted in the mechanism, and load links and a digital counter are set for the desired range. The tang of the wrench is then loaded hydraulically. At the break-away point, the counter displays the torque value in either pound-inches or pound-feet.

out device that displays the dimensions stored in the memory and the operation number, a tool compensator that can accommodate up to 100 different tool settings at one time, and a depth gage unit which contains dials for direct dimensional readout. New circuits required for depth control are coded to facilitate circuit tracing, and cable connections are plug-in type.

Automatic depth measurement is accomplished by the use of a train of Class A gages in a manner similar to that used for gaging and positioning the table. The gages are mechanically aligned by an electric drive. Manual depth setting may be accomplished by a series of direct reading dials that control mechancial stacking of the gages.

Whether under manual or tape control, the tool in a machine equipped with numerical depth control moves at a rapid approach rate until it is within 0.050-inch of the work surface. It then continues to advance at a preset feed rate until machining to depth is completed.

Automatic Test Set Collects Reliability Data

AUTOMATIC test data collection system for analyzing transistor quality and performance has been developed by engineers of the Semiconductor Div., Raytheon Co. The machine automatically performs 16 electrical tests and punches a data card with the exact values measured. A feature of the machine is a

ASSEMBLE PARTS FASTER . . . WITH FEWER REJECTS!

DPS model U power screwdriving machines

- Maintain constant driving torque with new positive control clutch
- Dependable motorized hopper drive with safety clutch protects motor and gears in the event of jamming
- Release screw by body or head with new feed track and escapement mechanism

Write today for DPS Model U Bulletin

You can drive up to 40 screws per minute with a DPS Model U. Nuts are driven equally fast . . . with accuracy that cuts parts waste, improves assembly quality.

DPS offers the Model U in two types: pedestal, and self-contained driving head. Both require minimum space and are readily adaptable to your work flow. Feed track and escapement mechanism mounts on either side of the machine column for right- or left-hand assembly. The versatile self-contained driving head is ideal for use in automatic assembly machines incorporating dials and straight-line transfers.

The Model U drives screws from #6 x 3/16" long to 1/4" x 1 1/2" long . . . and can be equipped with 12" or 16" barrel feeders.

DETROIT POWER SCREWDRIVER COMPANY
2811 W. Fort St. • Detroit 16, Michigan
A Subsidiary of Link-Belt Company

15,334

Circle 667 on Page 19

AT DEVLIEG BOOTH 431 • NMTBA EXPOSITION

new series

"Designated the model 'H,' our new Jigmil series provides greater range, is more rugged, easier to operate and more accurate."

"Available in spindle sizes ranging from 3" to 5", the new 3H, 4H and 5H machines greatly increase JIGMIL range for precision boring, milling, drilling and other operations. The new series introduces simplified controls, thermal control of main spindle bearings for increased accuracy . . . wider bed and table for added stability and working range . . . stainless steel way covers for positive protection . . . features that reach a new standard in JIGMIL accuracy, ruggedness and simplicity of operation. And like all JIGMILS, the 'H' series is available with the DeVlieg Diatrol direct dial dimensioning system or Tapac* —DeVlieg's own system of automatic tape control."

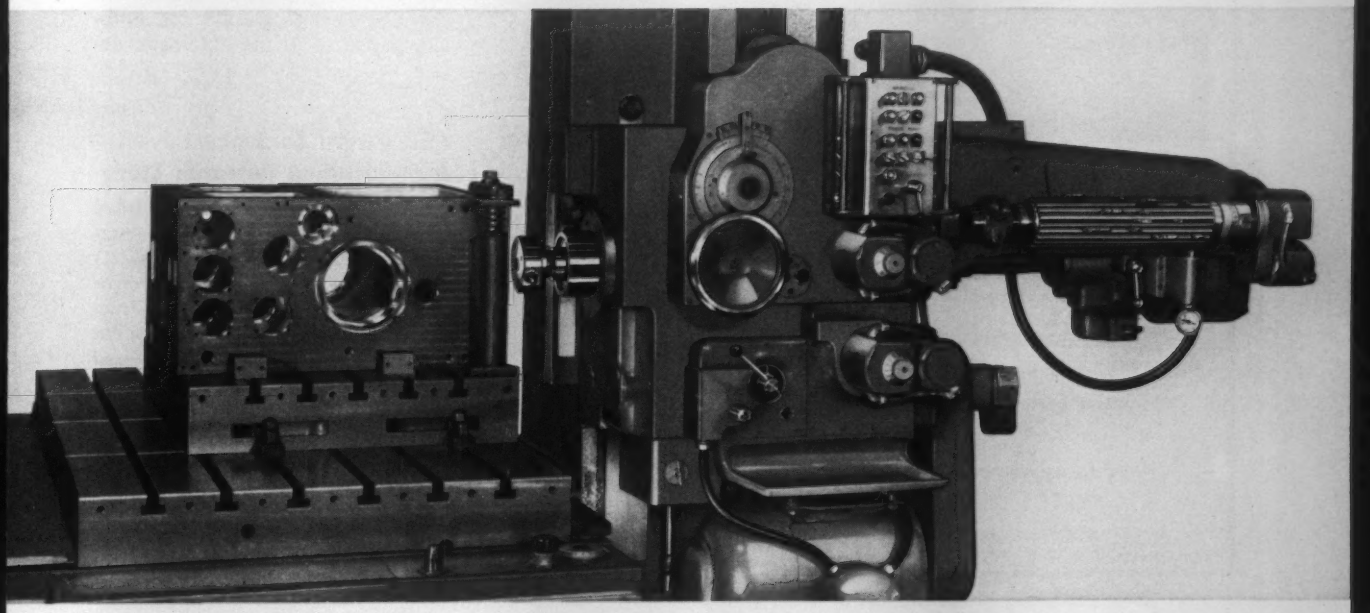
R. A. JERUE
Vice President in Charge of Engineering

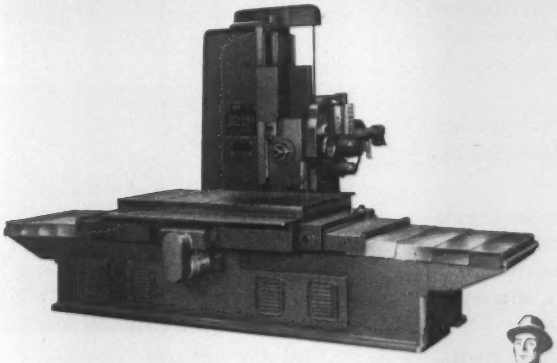
**Tape Automatic Positioning And Control*

DEVLIEG MACHINE COMPANY, FAIR STREET • ROYAL OAK, MICHIGAN

"H" Jigmils®

with Duplitrol • Diatrol • Tapac





Rewarding revelations in automatic precision await your next visit to Fair Street

Circle 668 on Page 19

MMT-PE

See new "H" series JIGMILS with DeVlieg Diatrol and DeVlieg Tapac in operation at the NMTBA Exposition, Chicago, September 6-16th.

Also, see in operation the new Micropoint Precision Tool Grinder—first grinder capable of absolute control of tool geometry.

DeVlieg

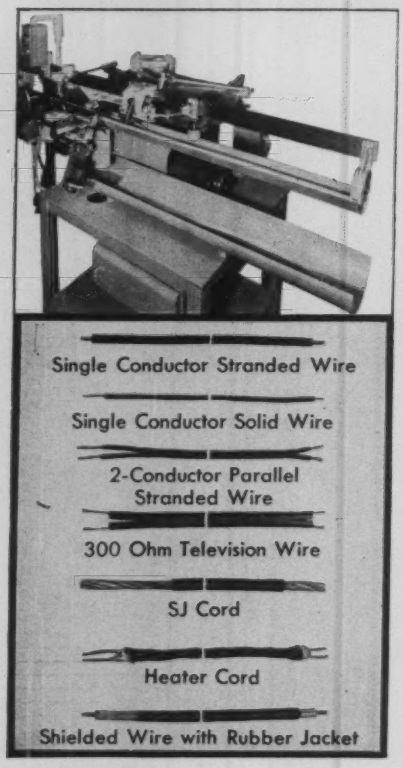
SPIRAMATIC JIGMILS®

ACCURATE HOLES AND FLAT SURFACES IN PRECISE LOCATIONS

Another Time and Labor Saver

for finishing wire leads

with ARTOS AUTOMATIC CS-6



A new collecting device is now available for use on the popular Artos CS-6 wire-measuring, cutting and stripping machine. Illustration shows the new collecting trough (AE-478). Upper trough collects wire leads up to 60 inches long, then empties into the lower trough after wire has been cut, thus saving operator time.

Production speeds of 3000 finished wire leads per hour up to 15 inches long. Maximum cutting length is 194 inches . . . stripping up to 2 inches at one or both ends. Artos also makes machines that measure, cut, strip and *attach terminals* automatically at one or both ends.

Operated by unskilled labor. Errors and work spoilage, due to human element, are eliminated. Machines are easily set up and adjusted for different lengths of wire and stripping.

Proved performance. Time-consuming hand stripping jobs which once were a bottleneck in many plants are gone forever. As a result, Artos automatic wire strippers are paying their way in the mass production of television and radio sets, electrical appliances, motor controls and instruments of all kinds.

If you need big capacity on wire lead finishing, WRITE for descriptive Artos Bulletin No. 36. Engineering consultation without obligation.

VISIT US AT BOOTH 119— WESCON SHOW

World Leaders in Automatic Machines for Finishing Wire Leads

ARTOS ENGINEERING CO.

2785 South 28th Street • Milwaukee 46, Wisconsin

jig on which 25 transistors may be mounted for testing. The jig is fed into the tester, the tiny units are evaluated, and test results are automatically recorded.

The equipment was developed in order to measure and record rapidly and accurately the characteristics of very large quantities of transistors used in life tests for reliability. For example, statistically, a minimum quantity of 23,026 transistors must be life-tested to demonstrate a failure rate of 0.01 per cent with 90 per cent assurance. Magnitude of the attendant data collection problem gave rise to the automatic device.

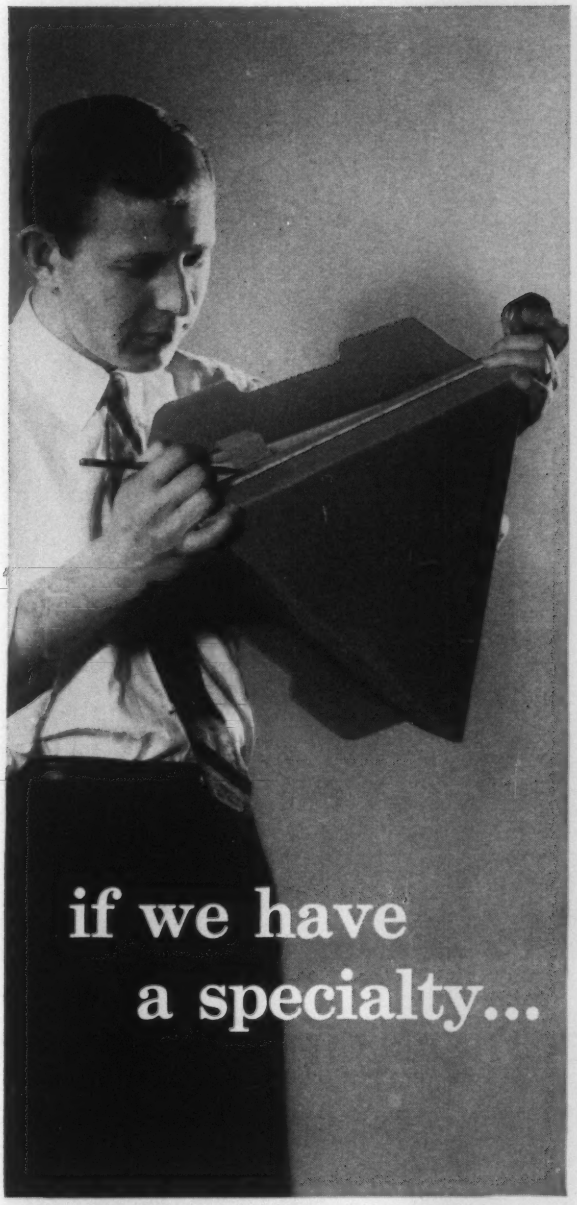
FIER Award To Support Manufacturing Research Study

GRANT of $5000 has been awarded by the Foundation for Instrumentation Education and Research (FIER) to **Dr. Gordon J. Murphy**, director of the Information and Data Processing Laboratory at Northwestern University. The grant will be used to help support a one-year research program aimed toward the advancement of instrumentation and automatic control technology.

The specific area of research to be conducted involves the application of feedback control theory to the design of production and inventory systems. According to Dr. Murphy, "Theory on electromechanical feedback control systems will be brought to bear on the general

DUAL-BEAM light scatter photometer is designed for continuous monitoring of atmospheres where dusts, aerosols, or other materials can affect health, safety, or manufacturing processes. Instrument, developed by Monitron Co., operates by chopping a single light beam into two beams. A photocell then compares, many times a second, the intensity of light reflected from particles scattered in the air with the intensity of a monitoring beam. The ratio of these intensities, an indication of atmospheric contamination, is shown on a meter and plotted on a chart.

Circle 669 on Page 19



if we have
a specialty...

...it's volume
production

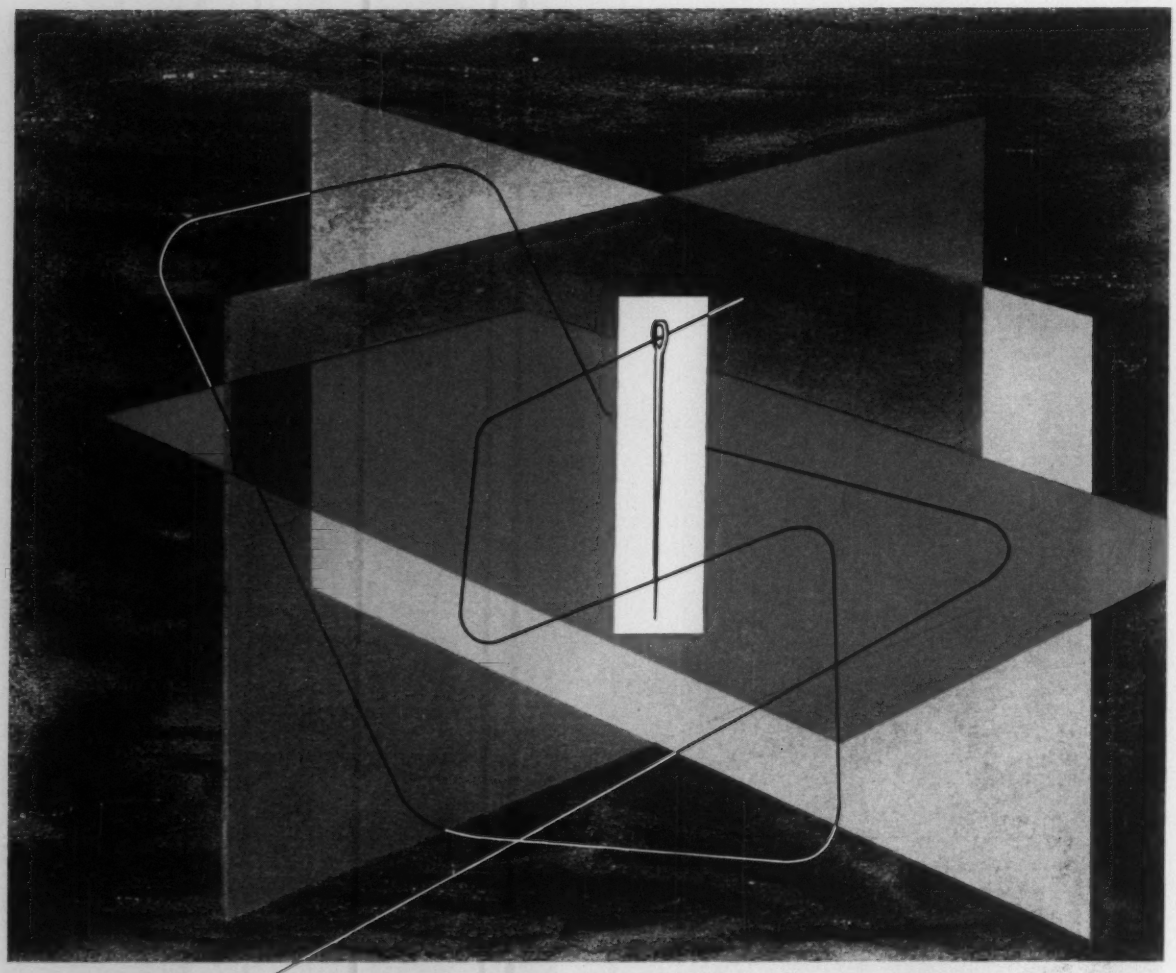
It's true that H & D has a reputation for solving thorny packaging problems with imaginative box design. But our real forte is *volume production of regular slotted corrugated boxes*—the kind you probably use to ship your product. In fact, H & D's annual output includes about 225,000,000 of these economical containers. Can you make use of this *specialty* for *volume?*

Hinde & Dauch Division

West Virginia Pulp and Paper

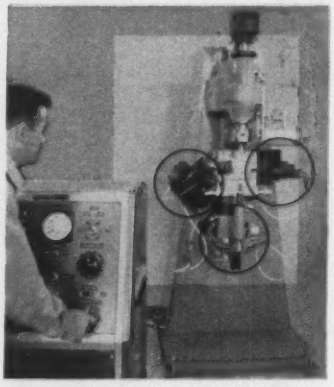
HINDE & DAUCH DIVISION, WEST VIRGINIA PULP AND PAPER, SANDUSKY, OHIO • 17 PLANTS • 42 SALES OFFICES

Circle 670 on Page 19



Needle-threading accuracy in 3 planes

This is what Leartron 60 series electronic servo positioners offer industry: instantaneous system response with pinpoint accuracy . . . designed and packaged for economy and ease of installation and maintenance. Adaptable to a wide variety of industrial uses, these systems are providing new levels of performance. Why not put Lear components and systems engineering to the test yourself? Write or call direct, GL 1-1555—extensions 272 or 310.



An in-use application of a Leartron positioning system on a vertical lathe for remote machining within a radioactive area.

Lear

industrial products

ELECTRO-MECHANICAL DIVISION

110 Ionia Avenue, N.W., Grand Rapids 2, Michigan

Circle 671 on Page 19

problem of the analysis and design of production and inventory control systems of various basic types. It is expected that these reseach activities will include both theoretical and experimental work and will lead to a more thorough knowledge of the effect on inventory and production levels of such factors as variable lead time, variable shipping delay, depreciation of inventory, shipping policy, and others."

Everyone Can Be An Expert In Computer Terminology

DO YOU know the meanings of computer terms such as *flip-flop, random access,* and *vocabulary?* Or do you blanch and suddenly remember a prior engagement when the conversation turns to computers?

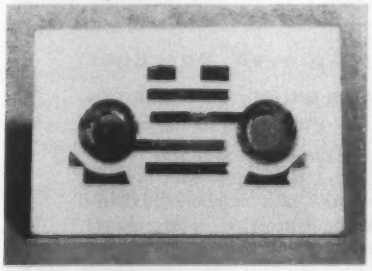
According to Minneapolis-Honeywell Regulator Co., these terms have the following meanings:

Flip-Flop. A device or circuit with two stable states. The circuit remains in either state until the application of a signal causes it to change.

Random Access. Equal access time to all memory locations, independent of the location of the previous memory reference.

Vocabulary. A list of operating codes or instructions available to the programmer for writing the program for a given problem for a specific computer.

These, and 79 other technical terms used by computer engineers in describing their complex appa-

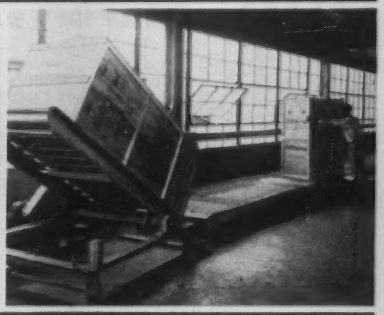


PRINTED circuits that can withstand high humidity, corrosive atmospheres, and temperatures up to 1800F have been developed by Mitronics Inc. The circuit board material is a high-alumina ceramic, and the metal circuits are a composition of molybdenum and manganese. Circuits are protected with an electroplated coating of nickel or copper, and connections may be made with hard or soft solder techniques. Boards with up to 18 square inches of printing area may be produced.

Avco Frigidaire John Sexton
NuTone I. B. M. Reynolds Metals
Timken Newberry Formica
Goodyear Int'l Harvester Delco
U. S. Plywood Admiral R C A
General Electric Ford Westinghouse
Du Pont National Biscuit P & G

CUSTOMERS OF BUSCHMAN
Use Conveyors as Varied as their Products

Buschman gravity and powered conveyors are carrying the load in every branch of industry. Wheels, rollers, belts, overhead and table-cable trolleys are coordinated in experience-engineered systems that expedite handling and save you money. With Buschman specifications and their standard stocked units, you can make the actual installation. Uniform Quick-Eez couplings permit fast assembly of portable units. Bolted construction facilitates moving fixed systems when required. Tell us your handling problems and let us suggest solution with low-cost, durable, efficient Buschman conveyors. The E. W. Buschman Company, 4551 Clifton Avenue, Cincinnati 32, Ohio.



Buschman
CONVEYORS

Complete Conveyor Systems for all Industries—Engineered, Manufactured, Installed
Representatives in Principal Cities, See Yellow Pages

367

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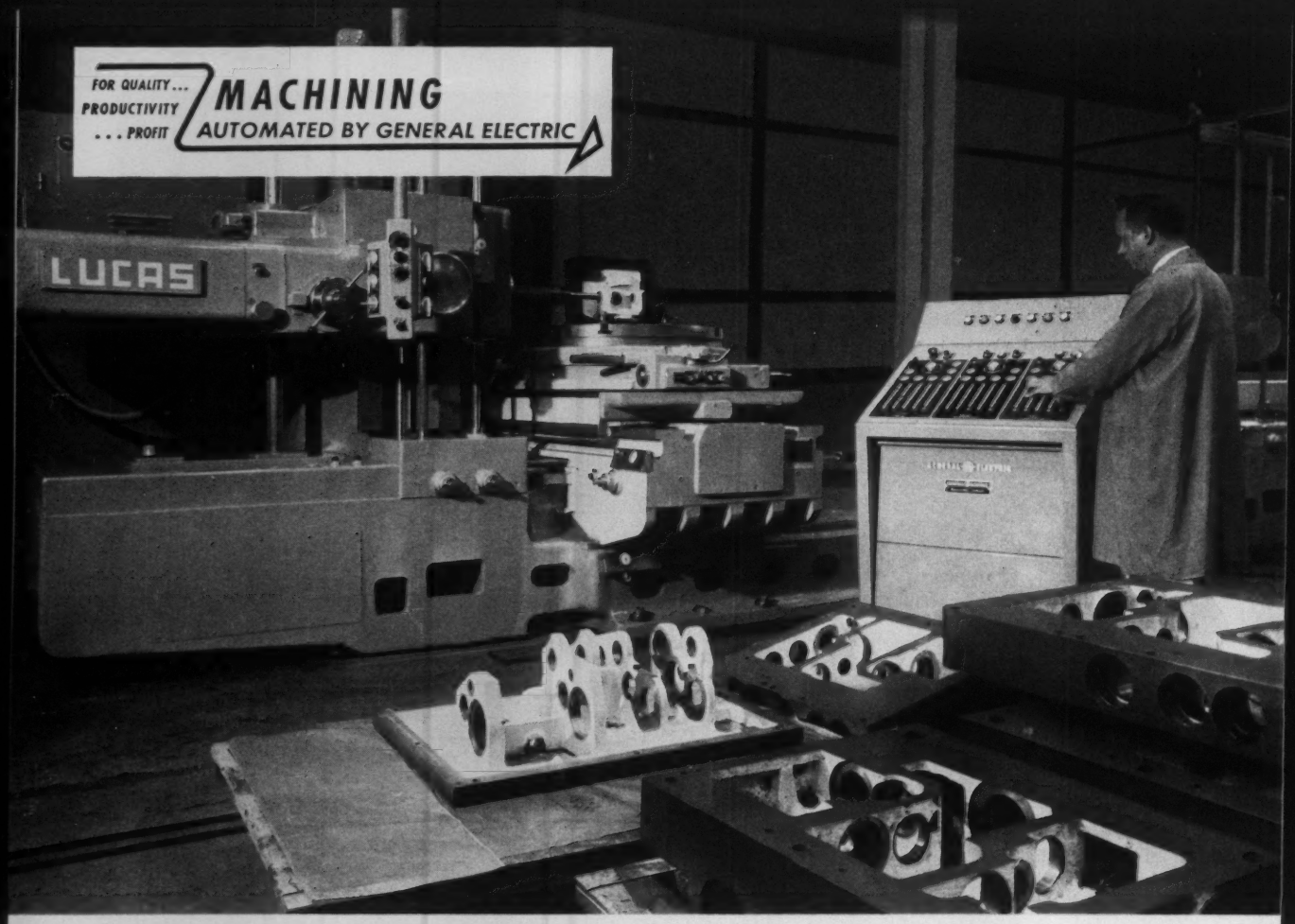


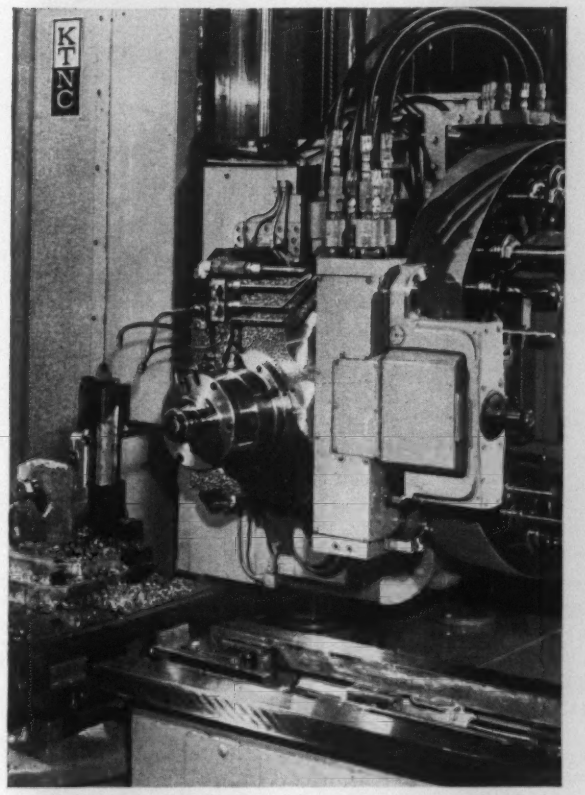
INCREASE MACHINE UTILIZATION

MARK SERIES NUMERICAL CONTROLS . . . . . standard, job-proved packages now in use on a wide variety of machines

General Electric's Mark series of standard, pre-engineered numerical control packages—with systems for controlling 1 to 5 motions plus machine auxiliary functions — are compiling impressive performance records on scores of machines throughout American industry today.

Machine operation is completely automatic—from punched tape prepared on a standard automatic typewriter. If desired, semi-automatic positioning, useful for prototype work, is obtained with manually set dials on the control station.

Key components of a typical Mark package are a controller, a punched tape reader, operator's control station, servo drives and position-sensing units.



ONLY ONE SETUP NEEDED to produce even highly complex parts on this G-E controlled multi-purpose milling, boring and drilling machine means dramatic savings. And, tooling savings on one group of 6 parts totaled $10,000.

83% LEAD-TIME REDUCTION is average for parts produced on this 6-spindle turret drill directed by G-E numerical control. Tooling costs are 40% of former methods. Tape data-storage saves expensive tooling space.

with General Electric numerical control

Move quickly from part to part, cut non-productive machine time

An idle machine . . . and an investment going to waste! This is the case in plants throughout metalworking today—perhaps including yours!

Many reasons are apparent: tool-room lag in making fixtures; long setups during changeover; excessive manual positioning; or, poor machine scheduling due to manual operation. Whatever the case, this adds up to something you cannot afford: high unit costs.

But, there is a solution! General Electric numerical control on today's modern machines provides increased machine utilization that signals the end of long lead times . . . multiple setups . . . long machining cycles . . . and, excessive in-process inventories.

Reports prove the advantages of G-E numerical controls. One user states that with G-E controls, his milling, boring and drilling machine is making chips 55% more of the time . . . setup time is cut 40% . . . and positioning time is 50% less. All this—plus a major reduction in parts inventories made possible by G-E tape control's ability to exactly reproduce a part at any future time—enabled this user to pay for his numerically controlled machine in less than two years.

In another case, a new multi-purpose milling machine—directed by G-E numerical control—selects 31 different tools automatically. Non-productive machine-cycle time is virtually eliminated, and complete part machining is possible on a *single* setup. On one small-lot part, 749 hours were saved. Tooling savings on a group of 6 different parts totaled over $10,000.

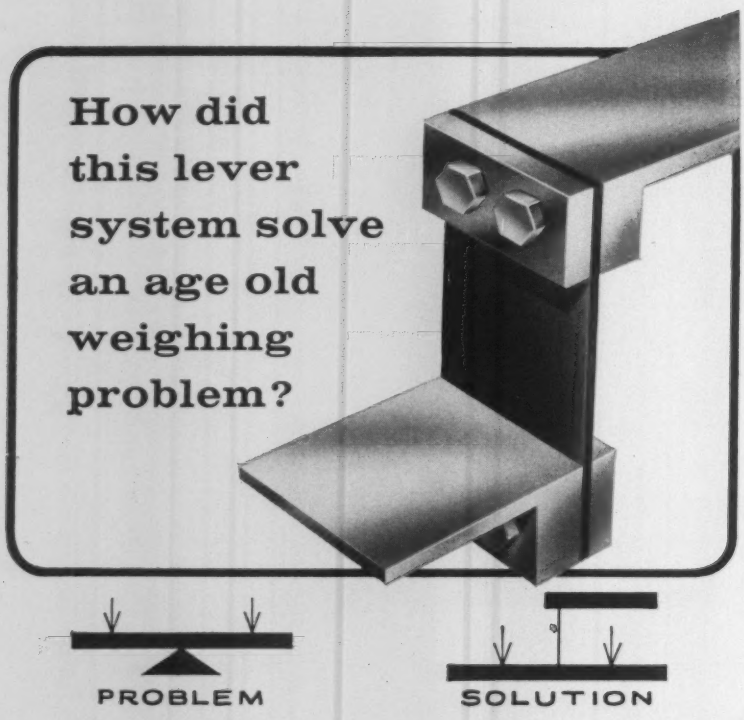
Join with these and hundreds of users who are increasing machine utilization and worker productivity, and eliminating special tooling cost with G-E numerical control. See your G-E Apparatus Sales Engineer or machinery builder today. General Electric Co., Specialty Control Dept., Waynesboro, Va. 795-8

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 673 on Page 19

How did this lever system solve an age old weighing problem?



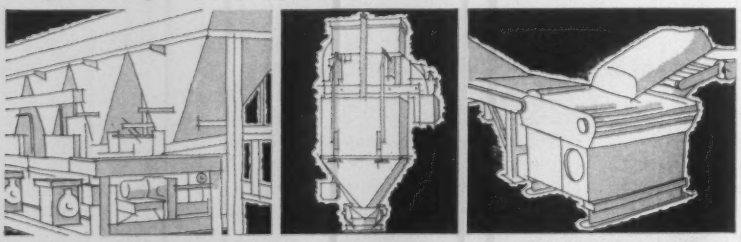
Early man was aware of the progressive inaccuracies of his pivot balance scales . . . but none knew how to remedy the situation.

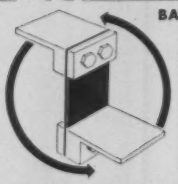
The problem was solved in 1956 when the United States issued a patent for a "Thayer Flexure Plate" Leverage System. A team of engineers and businessmen aware of industrys tremendous cumulative loss of materials in weighing operations, had devised a revolutionary new scale.

Knife-edge pivots that progressively wear and change were replaced by Thayer Flexure Plates that move only .001", yet accurately reflect the minutest changes in weight. This *firmly joined* lever withstands shocks and vibrations indefinitely. Dirt and dust are no longer a problem. Thayer guarantees this leverage system accurate for the life of the scale.

How Can It Save You Money Year After Year?

Working in conjunction with straight electrical controls, it forms the most reliable, low maintenance system ever devised to control processing or materials handling *by weight*. Literature on its application to filling, batching and checkweighing operations is available on request.





THAYER SCALE

AUTOWEIGHTION SYSTEMS FOR FILLING BATCHING AND CHECKWEIGHING

THAYER SCALE CORP. THAYER PARK PEMBROKE, MASS.

A Subsidiary of SUNDSTRAND CORPORATION

ratus, are defined in a 22-page glossary published recently by the company's Industrial Division.

Three NC Developments To Be Shown By Norden

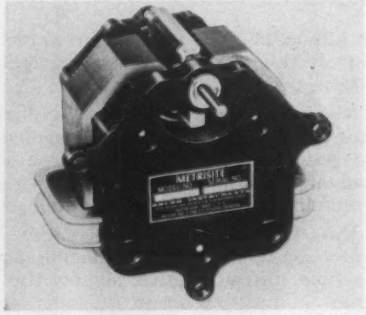
THREE of its latest developments in numerical control will be unveiled by Norden Div., United Aircraft Corp., at the Production Engineering Show to be held at the Navy Pier in Chicago from Sept. 6-16.

One of the developments is a display system which shows in decimal form the exact positions of important machine members, tools, or workpieces. In a typical application to a numerically controlled machine tool, a separate display would be used for each machine axis.

Each system includes a position feedback transducer, electronic circuits, and a visual display which can be read from a distance of 20 feet. The visual display can be mounted on the machine or at a remote location.

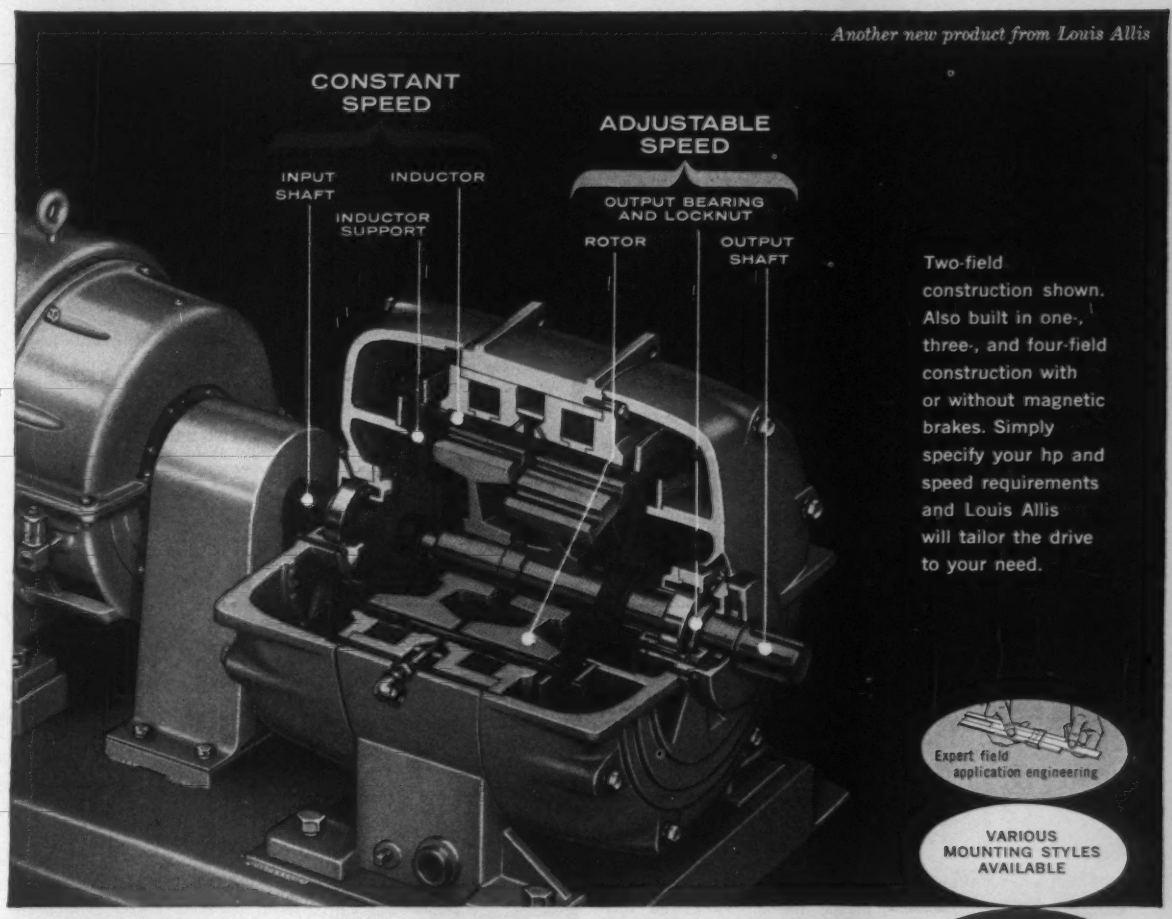
Also to be shown is an automatic positioning system that can accept inputs from either manually operated dial switches or punched tapes. The system incorporates display units that provide decimal readout of actual positions.

Both the display system and the positioning system can be supplied with full-range electronic origin select. Desired offset is obtained by



TRANSDUCER developed by Brush Instruments Div., Clevite Corp., measures angular displacements up to 40 degrees in either direction from a center position with a linearity of 0.25 per cent. Input to the device is from a 60 cps power source; output is an ac voltage proportional to angular displacement. Unit is suitable for industrial use and is said to operate satisfactorily under severe environmental conditions.

Another new product from Louis Allis


CONSTANT SPEED
ADJUSTABLE SPEED
INPUT SHAFT
INDUCTOR
INDUCTOR SUPPORT
OUTPUT BEARING AND LOCKNUT
ROTOR
OUTPUT SHAFT
Two-field construction shown. Also built in one-, three-, and four-field construction with or without magnetic brakes. Simply specify your hp and speed requirements and Louis Allis will tailor the drive to your need.
Expert field application engineering
VARIOUS MOUNTING STYLES AVAILABLE

The new Louis Allis MAGNETIC DRIVE

A compact, adjustable speed drive up to 2000 hp!

Based on a liquid-cooled magnetic coupling design, the *all-new* Louis Allis Magnetic Drive offers you the finest in precise regulation, compactness, and design flexibility for adjustable speed drives up to 2000 hp.

A unique annular cooling manifold provides effective heat transfer. It eliminates "water-drag" since there is *no* liquid in the air gap between the constant-speed and adjustable-speed members. There's no "flooding" the Magnetic Drive or forcing of water into bearings. And you'll *never* find condensation in the bearings. The reason: a planned flow of air through the drive reduces bearing temperatures and exhausts any condensation which might occur as the unit cools off after use.

Stationary field construction eliminates slip rings. All bearings can be lubricated without disassembly, and grease chambers provide ample grease reservoirs. Coils and lead connections are encapsulated in a chemical- and heat-resistant polyester — and simplified construction eases inspection and servicing. The *all-new* design permits simple relocation of cooling inlet, conduit box, discharge, etc., regardless of direction of rotation.

If your plans call for adjustable speed drives — specify Louis Allis Adjustable Speed Magnetic Drive. Write for a copy of Bulletin 3650 — now available at your Louis Allis District Office, or from The Louis Allis Co., 463 E. Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

ASD-135

Circle 675 on Page 19

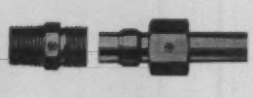
WEATHERHEAD

offers one source for all tube fitting needs... a complete line of flared, flareless or pipe...

TUBE FITTINGS of BRASS, CARBON or STAINLESS STEEL

BRASS FITTINGS

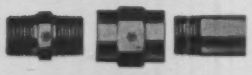
S.A.E. 45° FLARE
USED with copper, brass, aluminum, steel and plastic tubing. PRESSURE RATINGS up to 5000 p.s.i. **Sizes: ⅛" to ¾".** Also available in 37° heavy pattern brass. Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.



COMPRESSION
USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L.; approved by A.G.A. Meets specs of S.A.E. Hydraulic Tube Fittings Standards and A.S.A. and A.S.M.E. codes for instruments and control piping.

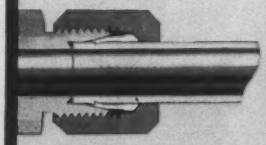
SELF-ALIGN®
No flaring, soldering, welding—insert tube and tighten nut. USED with copper, brass, aluminum and plastic tubing. PRESSURE RATINGS up to 2000 p.s.i. **Sizes: ⅛" to ¾".**

INVERTED FLARE
USED with copper, brass, aluminum, steel, Bundyweld and plastic tubing. PRESSURE RATINGS up to 3000 p.s.i. **Sizes: ⅛" to ¾".** Listed by U.L. Meets specs of S.A.E. Hydraulic Tube Fittings and A.S.A. and A.S.M.E. codes for instruments and control piping.

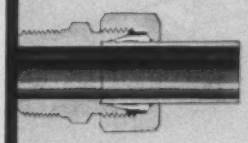


PIPE
USED with brass or steel pipe. PRESSURE RATING: up to 5000 p.s.i. **Sizes: to 2".** Meets specifications of S.A.E. TPHL Fittings Committee.

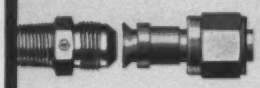
FORGED STEEL FITTINGS



"7000" SERIES ERMETO®
U.L. listed. Meets J.I.C. standards. S.A.E. approved "O" Ring boss design. Dryseal pipe thread. Needs no flaring. Available in either carbon or stainless steel. Carbon steel fittings have "Weathercoat" or cadmium-plate finish. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Ranges—⅛" through 2".**



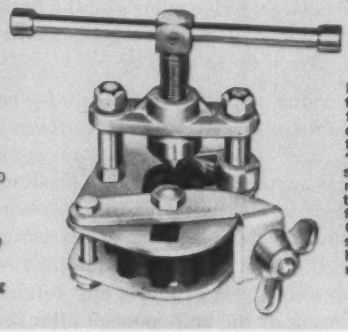
"8000" SERIES ERMETO®
Listed by U.L. for use with hazardous liquids, fuel equipment, refrigeration and gas; meets specs of S.A.E. and J.I.C. hydraulic tube fitting standards. Supplied as standard in cadmium-plate carbon steel and in stainless steel. Requires no flaring. PRESSURE RATINGS: up to 10,000 p.s.i. **Size Range—⅛" through 2".**



FLARE-TWIN—(2-pc. or 3-pc.)
37° FLARE STEEL TUBE FITTINGS
Listed by U.L. S.A.E. and J.I.C. approved. Used with J.I.C. and other soft steel tubing; also with copper, aluminum, and fully annealed stainless steel tubing. Meets S.A.E. standards for straight thread boss mounting. PRESSURE RATINGS up to 10,000 p.s.i. **Sizes: ¼" through 2".**

FLARE-TWIN
Made in 3-piece and 2-piece assemblies. 2-piece type offers price advantage. "Weathercote" or cadmium-plate finish.

FAST! EASY! ACCURATE TUBE WORKING TOOLS

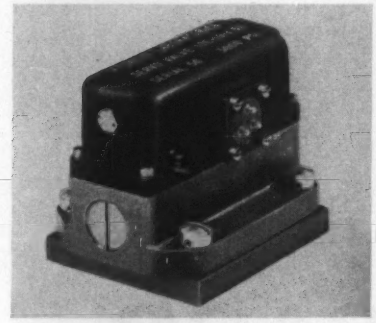


New rotary flaring tool for perfect tube flaring. Fast . . . one piece construction. Easier . . . "Dial - Matic" tube size selection. Accurate...tube stop automatically controls flaring diameter. Compact . . . easy to store. Available with burnishing attachment.

Spring-Type Bender | Mechanical Bender | Tube Cutter | Bar-Type Flaring | Tube Swaging | Automatic Flaring Rotary

THE WEATHERHEAD COMPANY

FORT WAYNE DIVISION • Dept. A-8, 128 West Washington Blvd. Fort Wayne, Indiana



ELECTROHYDRAULIC servo valve developed by Pegasus Laboratories Inc. weighs only 0.8 pound and delivers up to 2 gpm of fluid. Features of the unit include high spool-drive stiffness and symmetrical design to ensure sensitive operation without dither. Null shift is low over large ranges of operating temperature and pressure.

means of manual selector switches. The systems are also available with automatic tape punch units for tape preparation on the machine. This provides a programmed tape that can be used for playback applications or as a permanent inspection record for parts produced on the machine.

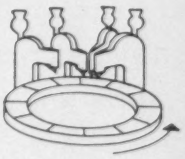
The third development permits automatic dimensional inspection of parts by measuring their shapes and contours. Since the location of each point on the surface of a part may be expressed in digital form, this information can be programmed. Corresponding points on the actual part can then be probed automatically and the dimensions compared with the programmed information. The inspection system can be provided with direct numeric print or readout of actual dimensions or deviations from nominal, or can give out-of-tolerance indications. Punched tape output is also available.

SPOTLIGHTING PEOPLE

John D. Heasley appointed manager of the Industrial Electronics Dept., Westinghouse Electric Corp. . . . **J. Richard Garvin** named manager of manufacturing of the Specialty Motor Dept.; **William B. Boyd** appointed manager of manufacturing of the Specialty Transformer Dept.; **Hicks B. Waldron** named manager of the Plainville, Conn., plant of the Distribution

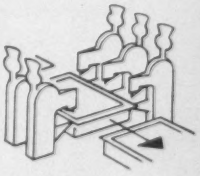
A FEW OF MANY POSSIBLE RIVETING HEAD POSITIONS THAT CAN BE USED

Rotating fixture showing suggested arrangement of riveting heads.

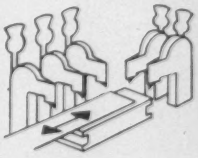


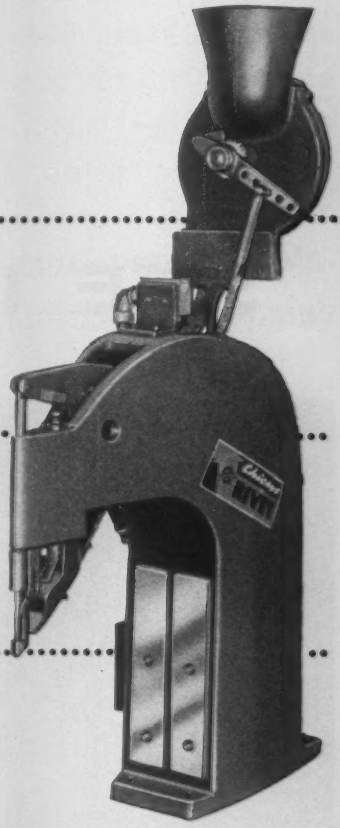
Riveting heads can be positioned for fastening on flat or curved assemblies.

Conveyor Belt permits multiple setting on both sides of an assembly.



Sliding fixture used for riveting 2 sides of an assembly.





AUTOMATE RIVET SETTING

for new low costs

For years assemblies made of metal and non-metal or a combination of both have been fastened most economically with semi-tubular rivets. And now even lower costs are possible with the thin-nose riveting heads designed by Chicago Rivet. These heads, pneumatically operated but electronically controlled, can be grouped in clusters on one or more planes and will set rivets as close as $^{13}/_{16}$" apart. Automation, thru rotating sliding or continuous belt feeding and riveting stations, is possible. Riveting heads may be repositioned and used again on new assemblies.

CUSHIONED RIVETING REDUCES BREAKAGE

A pneumatic riveter upsets the rivet with a squeezing action which minimizes breakage and automatically compensates for slight variation in assembly thicknesses.

The suggestions of Chicago Rivet fastening specialists will prove most helpful. Call them—no obligation.

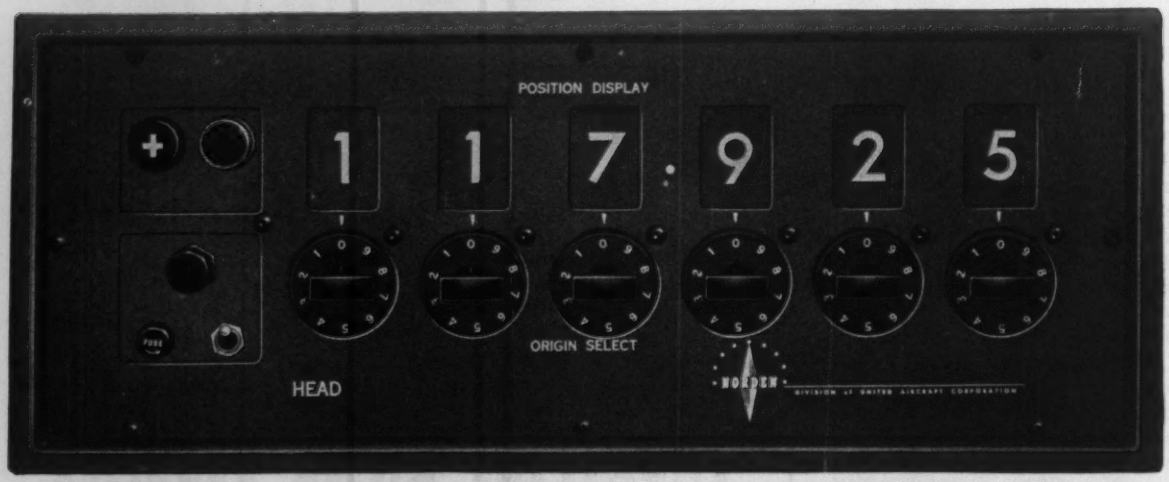
AIR-POWERED RIVETING CATALOG contains description and specifications of 8 single and multiple riveters—also rivet setters designed for automation.
RIVET CATALOG describes 1388 standard tubular and split rivets and 25 single and multiple motorized automatic rivet setters.

Chicago Rivet & MACHINE CO.

943 So. 25th Ave., Bellwood, Ill. (Chicago Suburb) · Branch Factory: Tyrone, Pa.

Circle 677 on Page 19

SEE IT AT CHICAGO



Modumatic Systems Control–Display

MEASUREMENT • POSITION • INSPECTION

NORDEN DIVISION

Norden Division of United Aircraft Corporation presents advanced but simple systems applicable to your need for faster, more accurate positioning of tool or workpiece

Norden Modumatic Systems feature readout of actual position, automatic positioning, full range origin select, and controlled programing

FOR MEASUREMENT

Series 100—This system displays in straight decimal form the exact position of the tool or workpiece. One display is used for each axis of motion.

Features—Illuminated numbers, readable from twenty feet—individual plug-in decimal units—display unit can be located on machine or remote.

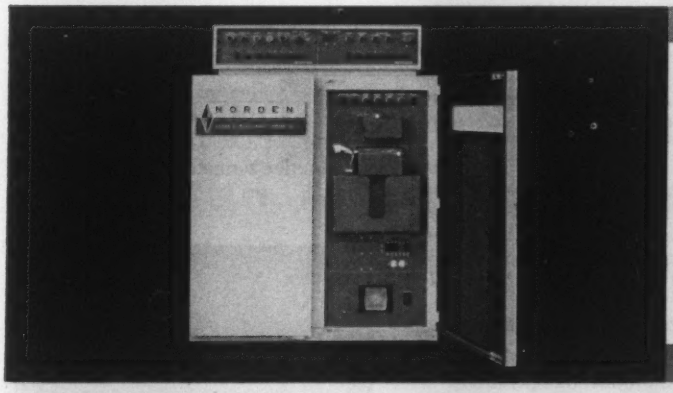
FOR POSITIONING

Series 600—A completely automatic positioning system with input from either manual dial-in switches or punched tape. Display units provide decimal readout of actual position—not command.

FOR INSPECTION

This new Norden concept now makes possible automatic inspection of parts by measuring their exact shape and contour. Since each point on the part's surface has a digital value this information can be easily programmed. Corresponding points on the actual part can be probed automatically and their dimensions compared with the programmed information. The system can be provided with direct numeric print or readout of actual dimensions, deviations from nominal, or out of tolerance indications. In addition, punched tape output is available.

Norden numerical control systems also offer full range electronic origin select. This allows any desired offset to be quickly and easily dialed in by the operator on manual selector switches. In addition, these systems are available with automatic tape punch units for tape preparation "on the machine." This provides a permanent inspection record or a programmed tape for playback applications.



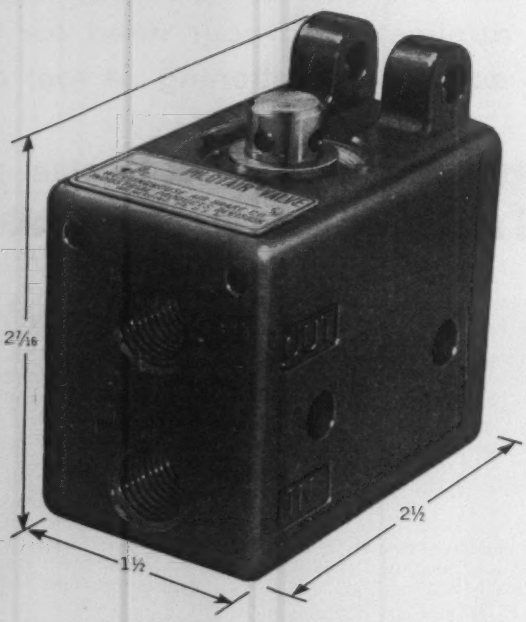
When in Chicago for the
PRODUCTION ENGINEERING SHOW, NAVY PIER SEE US AT BOOTH 221.
At the National Machine Tool Builders Show see Norden Controlled Machines exhibited by G. A. Gray Company, Booth 1350. Atlantic Machine Tool Works, Booth 543. LaPointe Machine Tool Company, Booth 1229.

For more information contact your nearest Norden Representative. 400 Main Street, E. Hartford, Connecticut, JAckson 8-4811. 11 West Monument Avenue, Dayton 2, Ohio, BAldwin 8-4481, or write us at the address below.

OF UNITED AIRCRAFT CORPORATION
DATA SYSTEMS DEPARTMENT
SANTA ANA, CALIFORNIA

Circle 678 on Page 19

another new Westinghouse AIR CIRCUITRY Component



Hand operated

Foot operated

Air pilot operated

Cam roller operated

Cam dog operated

Type "A" PILOTAIR® Valve

Don't let the size of these little poppet-type directional valves fool you.

They can open, close or vent an air circuit as quickly, efficiently and dependably as models twice their size.

For despite their compactness (actual dimensions are 1½" x 2½" x 2 7/16"—and they weigh less than 16 oz.), the short travel action of poppet valve construction produces fast response for full valve capacity.

Type "A" PILOTAIR Valves are enclosed in a solid, die cast aluminum block for ease of installation and ruggedness. They are designed for lever, mechanical or air operation. Maximum inlet pressure is 250 psi. Maximum operating temperature is minus 40°F to plus 200°F. Pipe taps are ¼" N.P.T.

AIR CIRCUITRY—FOR TROUBLE-FREE AUTOMATION

Air Circuitry is the application of pneumatic control systems to industrial production operations.

Air circuits are safe, economical and precise and are used to solve the most rigorous and complex control problems in industry.

Our engineers, backed by 90 years of experience, can help you boost production and cut costs in your plant.

AIR CIRCUITRY means trouble-free automation

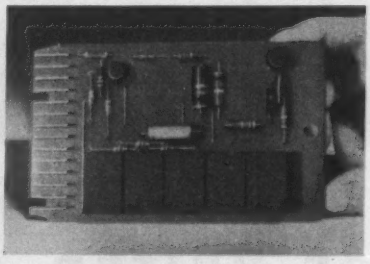
For more information, ask for Catalog A4-74:00

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

Assemblies Dept.; and **Alfred J. Carletti** appointed manager—headquarters manufacturing of the Distribution Assemblies Dept.; all departments of General Electric Co. . . . **Dr. Emanuel R. Piore** elected vice president for research and engineering at International Business Machines Corp. . . . **Duncan B. Gardiner** appointed manager—Corporate Engineering for Vickers Inc. . . . **Merritt B. Sampson** elected vice president—engineering for the S-P Mfg. Corp. . . . **Bernard M. Van Enden** named chief research engineer of Automation Development Co. . . . **R. A. Emmett Jr.**, vice president of Detrex Chemical Industries Inc., assumed responsibility for all chemical and equipment manufacturing at the firm. . . . **Roland Hecker** appointed chief engineer of Burg Tool Mfg. Co. Inc. . . . **Ray A. Zuck** named vice president in charge of design and production of material handling systems at Atronic Products Inc. . . . **Tom Gahafer** appointed Western Region specialist for the Automation Controls Dept., General Controls Co. . . . **Robert A. Loddengaard** joined Servo Corp. of America as servo instruments section manager, Industrial Products Engineering. . . . **Werner I. Senger** appointed vice president in charge of engineering at Gisholt Machine Co. . . . **Thomas E. Ban** elected vice president—research of McDowell Co. Inc. . . . **George E. Comstock III** appointed chief engineer of Potter Instrument Co. Inc. . . . **Herman O. Mueller** named head of a newly



MAGNETIC shift register developed by Magnetics Research Co. Inc. provides nondestructive readout with only one core per bit stored. With the unit, a stored pulse pattern may be read out repeatedly without destroying the information stored. Input may be serial or parallel. Nondestructive readout occurs in parallel on command from a separate input; the register may be cleared by reading out serially in the normal manner.

For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

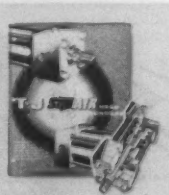
That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application – with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

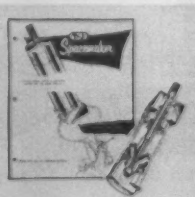
THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.



SQ-1058-4 for the T-J Squair Head cylinder.

No. 54 for standard tie-rod air cylinders.



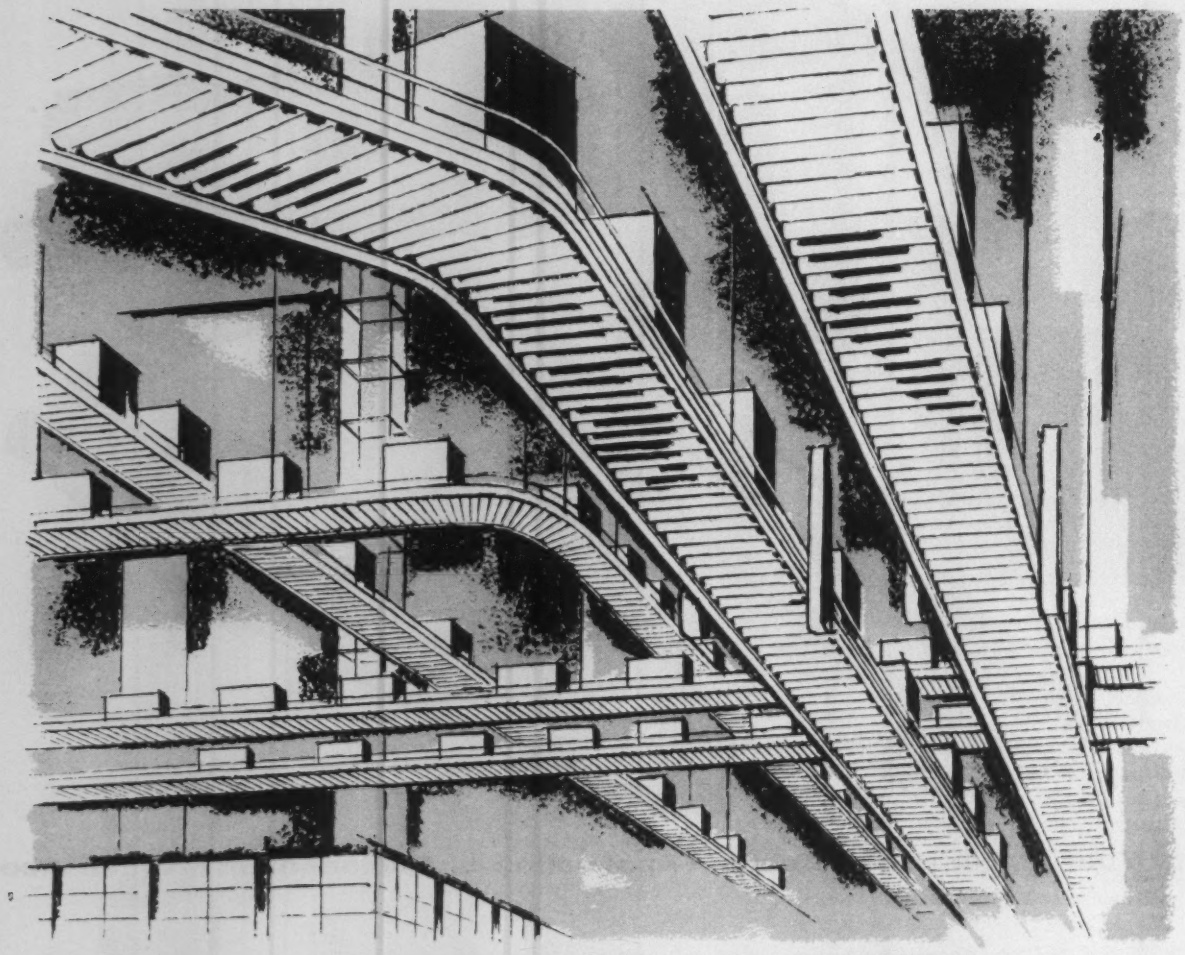
SM-56-3 for the incomparable Spacemaker cylinder.

HSM5-56-4 for the High-Pressure Hydraulic Spacemaker cylinder.

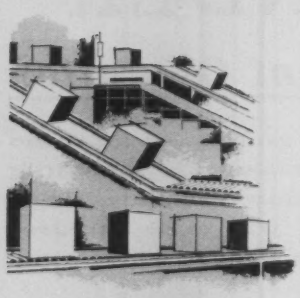
THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS

Circle 680 on Page 19



DO YOU THINK YOU NEED A BIGGER PLANT?



Does your plant seem crowded? You could build a bigger one—but do you really need to?

The solution to problems like these is Alvey Conveyor's business.

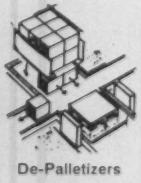
Maybe your time-lags, back-up on production lines, and crowded storage areas are the result of poor coordination between the separate elements of your system—or out-of-date handling methods.

Let a team of Alvey engineers look at your layout. They can show you how to keep your material moving and your space available.

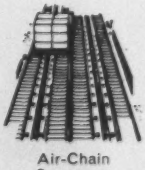
Whether you need a complete system or single material handling device . . . call or write Alvey for free consultation.

Vertical Lift Conveyors

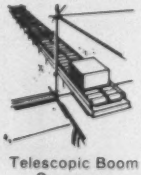
Pallet Loaders



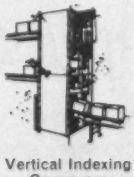
De-Palletizers



Air-Chain Conveyors



Telescopic Boom Conveyors



Vertical Indexing Conveyors

ALVEY CONVEYOR MANUFACTURING COMPANY

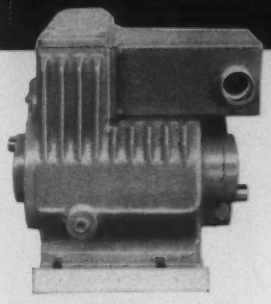
9373 OLIVE STREET ROAD, ST. LOUIS 32, MO. *Branch Offices in Principal Cities*

Circle 681 on Page 19

formed Special Products Development Dept. of the Liquidometer Corp. He will be responsible for the design and development of diversified control and measurement systems and other company products. . . . **Thomas P. Bonacuse** and **Rodney G. Rockwell** appointed to the Industrial Systems Dept.; and **George J. Bartolomei, Roland Schroder,** and **David A. Zinder** named to the Control Dept.; both departments of Allis-Chalmers Mfg. Co. . . . **Henry Petronis** elected vice president—manufacturing of the Pall Corp. . . . **Duane H. Carlington** joined Cargill Detroit Corp. as an account engineer.

SPOTLIGHTING PLANTS

Crompton & Knowles Packaging Corp. has enlarged its engineering department to provide more complete engineering services to its customers and to allow for a broadened, new machinery development program. . . . **H. Fischer & Associates Inc.,** engineering consultant, has purchased all assets of May-Fran Mfg. Co., manufacturers of steel belt conveying systems and special purpose equipment and machinery. . . . **Lamson Corp.** has formed a new Western Division, located in San Francisco, to manufacture materials handling equipment for Western States users. . . . **General Electric Co.** is planning to add 260,000 sq ft of office, engineering, and manufacturing space to its transistor and tunnel diode facilities at Electronics Park, Syracuse, N. Y. The addition will more than double present facilities. . . . **Rochester Mfg. Co.** has embarked on a long range research and development program aimed at the introduction of new products, mechanization of manufacturing operations, and general growth of the company and its subsidiaries in Illinois and California. The company presently manufactures liquid level, temperature, and pressure gages for commercial and military applications. . . . **Melpar Inc.** is adding a $2.4 million, 120,000 sq ft wing to its present facilities in Falls Church, Va. . . . **Constructors John Brown Ltd.** of London, England, is opening a permanent overseas office in New York City. The company is a complete construction, engineer-



Seneca Falls Mechanical Power Amplifier with two phase Servo Motor as control input device.

The Seneca Falls MECHANICAL POWER AMPLIFIER is a simple, power servo drive in striking contrast to the more complex electrical and hydraulic devices. Years of Service in rugged applications prove its dependability, long life and negligible maintenance.

SHAPED AUTOMATICALLY BY THIS SENECA FALLS MECHANICAL POWER AMPLIFIER

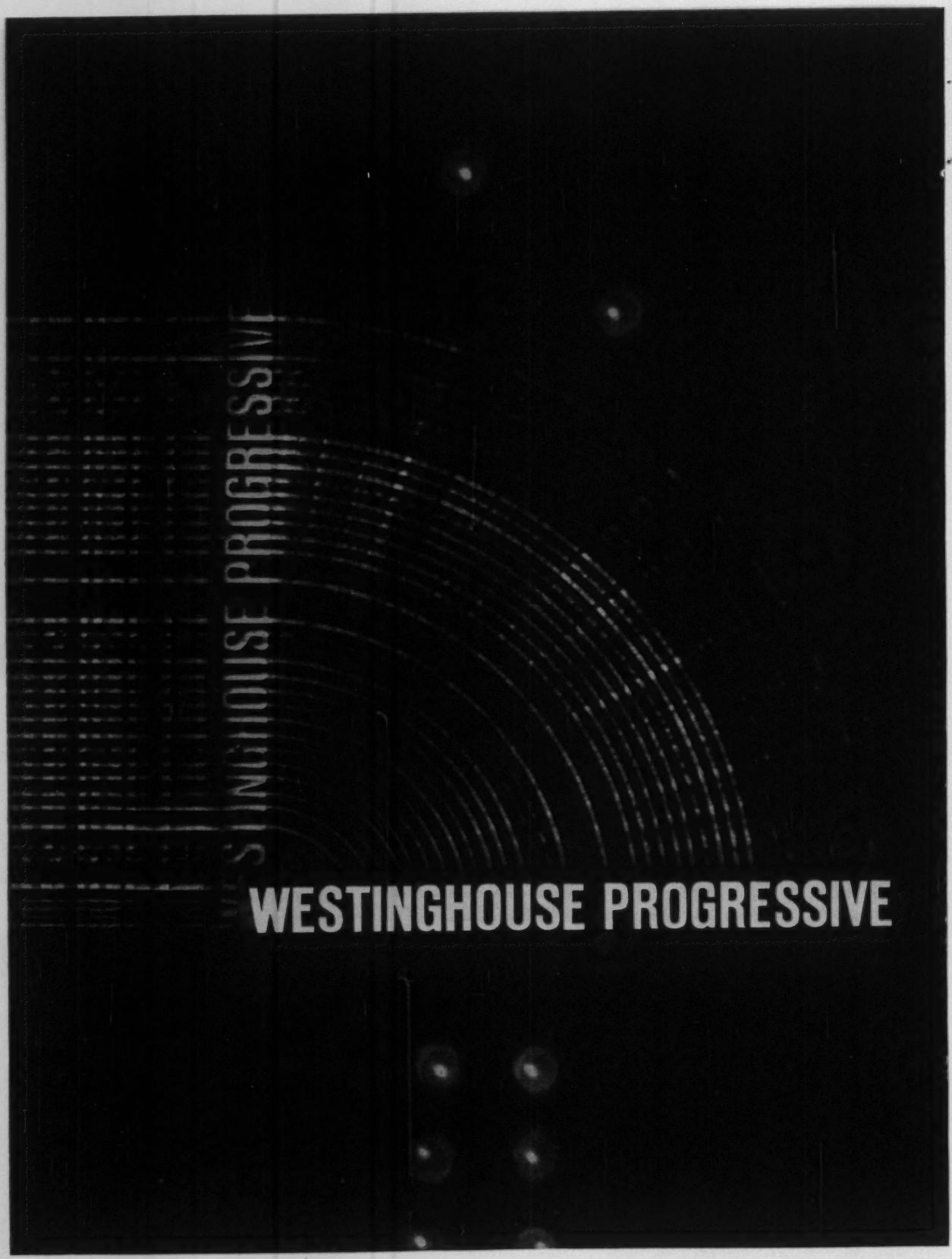
Insulators, like the partially finished one pictured, used to be shaped by hand-held tools—much as a hobbyist operates a wood turning lathe. Now a Seneca Falls Two-Axis Servo Drive utilizing the Mechanical Power Amplifier shapes more insulators better, faster and at lower cost.

Whatever your control problem, investigate this simple, easily maintained Power Servo Drive that will amplify torque from *any* control input device. Its excellent dynamic response permits the design of high sensitivity control systems. Write for Technical Bulletin EE 1009.

SENECA FALLS MACHINE
PIONEERS IN AUTOMATION

SENECA FALLS, MACHINE CO.
ELECTRONICS DIV. • SENECA FALLS, N. Y.

Circle 682 on Page 19


WESTINGHOUSE PROGRESSIVE

WESTINGHOUSE PROGRESSIVE AUTOMATION CAN HELP YOU IMPROVE OUTPUT, PROFITS THROUGH COORDINATED AUTOMATIC PRODUCTION

AUTOMATION

Westinghouse *Progressive Automation* is a long-term plan leading to automated production with minimum capitalization. It is designed to help manufacturers gain better product quality through step-by-step control of operations.

In fact, *Progressive Automation* has already been carried to its logical conclusion: completely automatic production. In the steel industry alone, three computer-controlled systems have been sold. Here the entire drive systems, supplied by Westinghouse, provide coordination of rolling mill operations under the command of a computer.

AUTOMATION... STEP BY STEP—Westinghouse is ready to work with you in planning economical steps to automatic operations . . . without under- or over-automating. Step-by-step automation starts with the many modern Westinghouse controls, motors and drives at work in plants today. Each was designed to achieve an immediate production objective . . . to control a single machine, a conveyor line or an entire installation. Through *Progressive Automation*, you next add other Westinghouse coordinating controls and systems—all of which are compatible with those already in place. Your eventual target may be all production facilities fully coordinated with the Westinghouse industrial control computer.

PROGRESSIVE AUTOMATION ALREADY AT WORK—*In the paper industry*, PULSETTER* makes possible new standards of accuracy and product quality in paper production. The PULSETTER control system uses digital circuitry to maintain accurate synchronization of the speed *and* position of all sections of a paper machine. Accuracies can be maintained to only a 5″ variation in 2000 feet of paper.

In the chemical processing industries, Westinghouse provides OPCON* which experiments, then finds and controls optimum production efficiency.

For the primary metals industry, installations of Westinghouse PRODAC* (programmed digital automatic control) have improved product quality and mill functions, as well as monitoring all phases of the product and process by data accumulation systems.

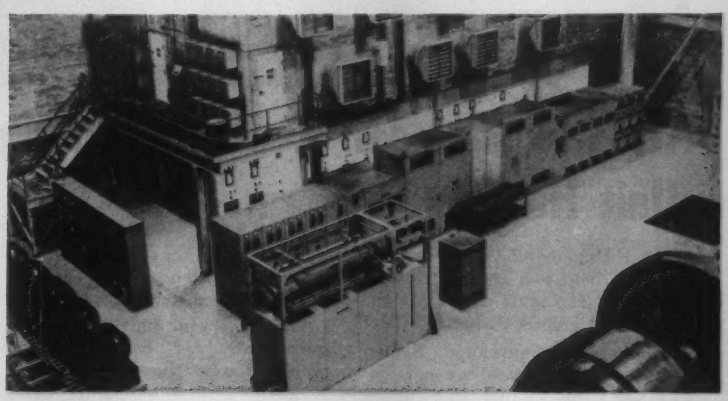
For the first time, there is now one source for all your automation needs: Westinghouse computers, controls, drive systems, transformers, motors, gearing, switchgear . . . and Westinghouse assumes full electrical system responsibility.

Call on Westinghouse and detail your objectives. We are prepared to work out your automation plan . . . furnish, install and maintain the necessary electrical equipment. Your Westinghouse representative has complete details on *Progressive Automation*.

*Trade-Marks

J-96144

PRODAC control computers are designed to work in unison with conventional control equipment. Result: full automation of plant or process becomes a practical reality.



YOU CAN BE SURE... IF IT'S Westinghouse

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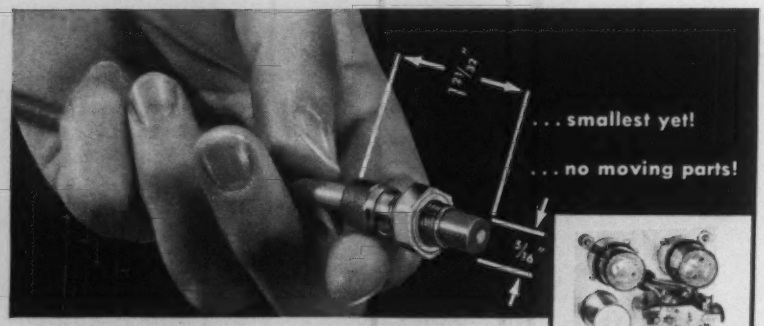


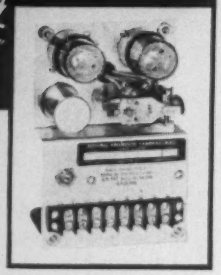
LOWEST PRICE...SMALLEST

Proximity Switch

OBTAINABLE!

Actuated by NON-MAGNETIC and MAGNETIC metals to solve electrical switching problems

Now Electro offers you a low cost proximity switch incorporating the basic *patented* circuit used successfully in industrial plants for more than 5 years.



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users net includes:

Control amplifier 4902
Sensing head 4910-BL
Connecting cable

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Electro CHICAGO

Write for new detailed Bulletin EDPS-80!

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Canada: Atlas Instrument, Ltd., Toronto

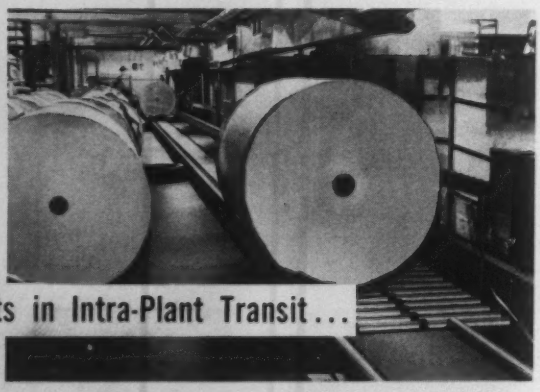
Most complete line of Proximity Switches and Magnetic Transducers · Tachometers · DC Power Supplies

Circle 664 on page 19

Whatever The Unit Form —

- Rolls
- Cartons
- Crates
- Coils

Or Components in Intra-Plant Transit...



A-F Can Engineer A Cost Reducing Unit Handling System—For YOU!

An A-F Engineered Conveying System can help you receive, process, store and ship units with more efficiency and greater dispatch.

The A-F Conveying System shown above not only increased usable floor space 25%, but brought new efficiencies with a "FIFO" (first in - first out) arrangement.

Whatever *your* unit handling requirements, A-F engineering can help you solve them.

Write us, without obligation, today.

A-F

A-F *ENGINEERED* CONVEYING SYSTEMS

Also Pre-Engineered Conveyors — Wheel, Trolley, Roller, Belt Metal Cleaning and Processing Machines

THE ALVEY-FERGUSON CO. 173 Disney St. Cincinnati 9, Ohio

Circle 685 on Page 19

ing, design, purchasing, and commissioning organization capable of handling contracts of any size in the chemical and oil industries. The company also maintains a number of departments specializing in pipelines, instrumentation, cathodic protection, counter-current processes, and fatty acid plants. . . . **Hanson-Van Winkle-Munning Co.** has completed expansion of its manufacturing facility in Grand Rapids, Mich. The addition of reaction, filtration, and mixing equipment increases the production capacity of the plant from 15,000 to 45,000 gallons per month of proprietary and other chemicals for electroplating and related metal finishing processes.

MEETINGS AND EVENTS

Aug. 7-13—

Eleventh Annual Industrial Research Conference. Scheduled for Arden House, Harriman Campus, Columbia University, New York. Further information available from M. F. Garvey, 409 Engineering Bldg., Columbia University, New York 27, N. Y.

Aug. 8-12—

American Institute of Electrical Engineers. Pacific General Meeting to be held El Cortez Hotel, San Diego, Calif. For details contact institute headquarters, 33 West 39th St., New York 18, N. Y.

Aug. 15-17—

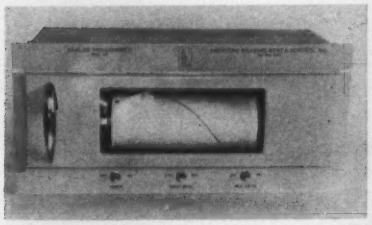
Heat Transfer Conference and Exhibit. Cosponsored by American Society of Mechanical Engineers and American Institute of Chemical Engineers to be held Statler-Hilton Hotel, Buffalo, N. Y. More information available from ASME headquarters, 29 West 39th St., New York 18, N. Y.

Aug. 16-19—

Society of Automotive Engineers. National west coast meeting to be held Jack Tar Hotel, San Francisco. Information available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Aug. 23-26—

Western Electronic Show and Convention. Cosponsored by Western Electronic Manufacturers Association and Seventh Region of



ANALOG programmer developed by American Measurement & Control Inc. converts a single-valued function (Y) drawn on graph paper with conductive ink into a proportional voltage as a function of time (X). The unit consists essentially of a chart-supporting drum, a resistive roller or potentiometer, and two contact rollers. A synchronous motor with gear changer provides driving force for the drum. As the X-axis varies linearly with time, an output voltage proportional to the ordinate of the curve is picked off at the point of contact between the potentiometer and the conductive, drawn curve. If a servo motor is used to drive the drum, the drum position can be a function of an independent variable.

Institute of Radio Engineers to be held Memorial Sports Arena, Los Angeles. Further information available from WESCON headquarters, 1435 South La Cienega Blvd., Los Angeles 35, Calif.

Aug. 23-25—

Association for Computing Machinery. National conference scheduled at Marquette University, Milwaukee, Wis. For information contact Arthur C. Moeller, Marquette University College of Engineering, 1515 W. Wisconsin Ave., Milwaukee 3, Wis.

Sept. 6-16—

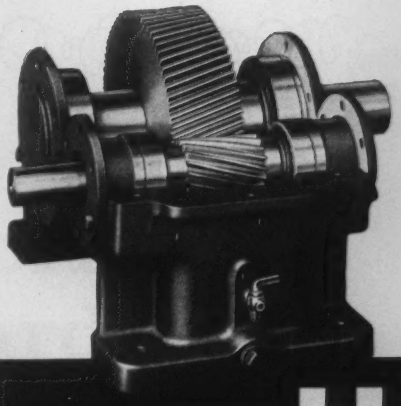
The Machine Tool Exposition—1960. Sponsored by National Machine Tool Builders' Association to be held International Amphitheatre, Chicago. Additional information available from association headquarters, 2139 Wisconsin Ave. N. W., Washington 7, D. C.

Sept. 6-16—

Production Engineering Show. Will be held Navy Pier, Chicago. More information available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 7-8—

Electronic Industries Association. Second conference on value engineering scheduled for Disneyland Hotel, Anaheim, Calif. Further in-



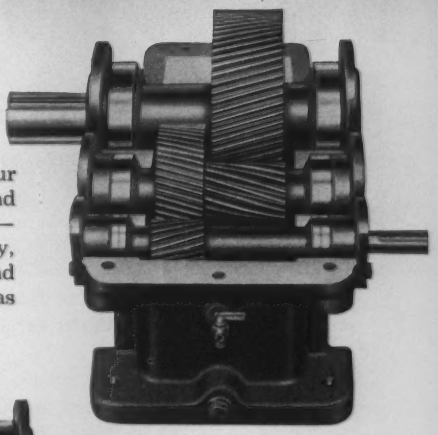
Fast Delivery on Custom Requirements

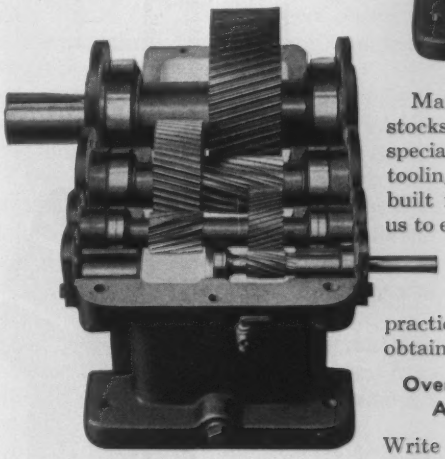
Specify H&S Helical Speed Reducers

Single · Double · Triple Reduction

You get *fast action* when you come to Horsburgh & Scott with your speed reducer and gearing problems.

We are able to meet your specifications—or design and build to your specific needs—products of highest quality, backed by the experience and reputation of many years as leaders in the gearing field.





Maintaining one of the largest stocks of patterns and blanks . . . special equipment and special tooling—much of it designed and built in our own plant—enables us to engineer and produce a wide range of custom gearing and transmission requirements, economically and practically as fast as you can obtain them from stock sources.

Overall design conforms to AGMA specifications

Write for details on wide size and capacity range of H&S Speed Reducers—Helical, Herringbone, Worm Gear and combinations.

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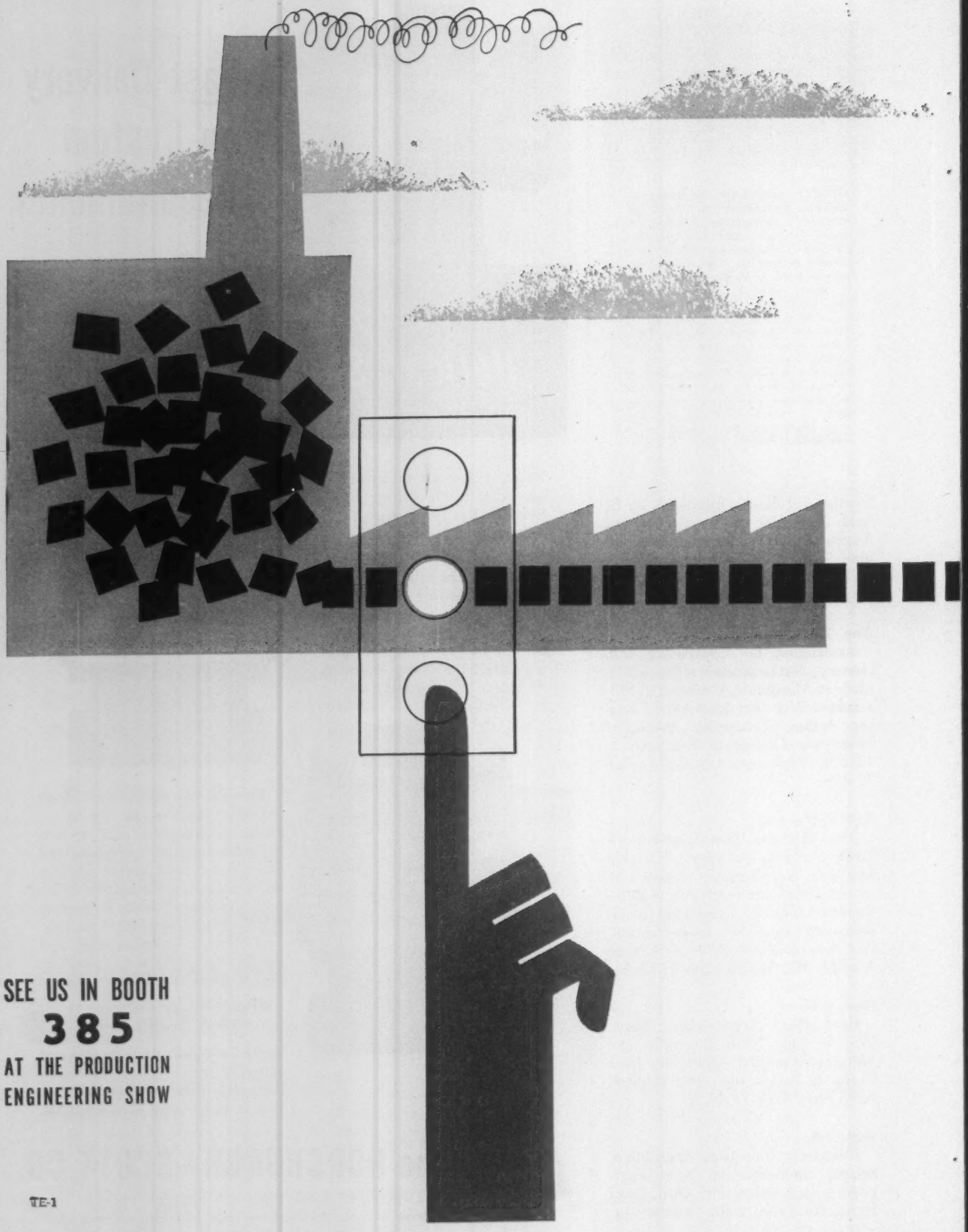


SEE US IN BOOTH

385

AT THE PRODUCTION
ENGINEERING SHOW

TE-1

Are you working toward automatic machine tool control?

The means by which instructions are reduced to the language of machinery and conveyed as intelligible orders to that machinery comprises the system complex which makes automatic control possible.

For many years North Electric has been designing, engineering and manufacturing such system complexes, over 5,000 of which are in operation today!

The selection and application of components, a thorough understanding of advanced switching techniques and complete familiarity with complex circuitry design are but three of the many highly specialized areas demanding unique capabilities and which are frought with danger for the uninitiated. This is the professional climate in which the experienced, system-concept-minded engineering group at North Electric works constantly and continuously!

If you are working toward automatic control of machine tools and automation of production machinery, you cannot help but profit when you call on the most experienced system group available.

If these are your goals—you'll want NORTH on your team. Write, wire or phone for an appointment to learn how much North can do for you.

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

628 S. Market St. *GALION, OHIO*

Circle 687 on Page 19

WHO cut out WHAT word from the dictionary?

im-pos"si-bil'i-ty, *n.* [-TIES, *pl.*] **1.** The fact or state of being impossible. **2.** That which is impossible; something that can not exist or be done.—**im-pos'si-bly,** *adv.*

THESE **are the men who cut it out:**

. . . part of the staff of Automation Engineering Laboratory, Incorporated . . . engineers, designers, inventors . . . yes, even dreamers. They have consistently solved "unsolvable" manufacturing, handling or processing problems . . . have designed and built "impossible" machines . . . that worked! They have done this for companies among the top five in such varied fields as Automotive, Electrical, Food, Paper, Textiles . . . etc.

Most important: in developing, designing and producing new or improved machines, processes and automated systems for industry, Automation Engineering Laboratory *has virtually eliminated costly risks of clients' capital!* How? By AEL's new concept of "STEP-BY-STEP Automation"®.

WHAT IS IT?

Briefly . . . it is AEL's systematic, step-by-step approach to creating equipment and processes. It involves *proving out* planned functions on working models . . . *one step at a time.* Function "A" is contracted for, completely proved out and demonstrated to you before Function "B" is even attempted . . . and so on. *Thus you will see your project operating in prototype within the first 15% of your total expenditure.* And, when your machine or system is completed, *it will work exactly as it should!* This is automation that any manufacturer can afford.

NOW...ABOUT YOUR PRESENT PROBLEMS

Whatever your automation problem, may we suggest you write or phone us? One of us will visit you . . . listen carefully to your problem . . . gather information. After studying your over-all layout, he will go back to Stamford and share your problem with other AEL Senior Staff Members. What he will then tell you is *"We can do it!"* and . . . on a contract basis you will appreciate.

Remember, the word "impossibility" has been cut out of our dictionary. Try us.

AUTOMATION ENGINEERING LABORATORY
INCORPORATED

● **AEL Development and Research Division, Inc.**
AEL Manufacturing Division, Inc.
AEL Food Machinery Division, Inc.

84 Commerce Road · Stamford, Connecticut

Circle 688 on Page 19

formation available from association offices, 11 West 42nd St., New York 36, N. Y.

Sept. 7-9—

Joint Automatic Control Conference. Cosponsored by ASME, AIChE, AIEE, IRE, and ISA to be held at Massachusetts Institute of Technology, Cambridge, Mass. For further information write Wm. D. Archibald, Energy Control Co., 5 Beekman St., New York 38, N. Y.

Sept. 7-15—

Coliseum Machinery Show. Scheduled for Coliseum, Chicago. Information is available from A. Byron Perkins & Associates, 2807 Sunset Blvd., Los Angeles 26, Calif.

Sept. 12-14—

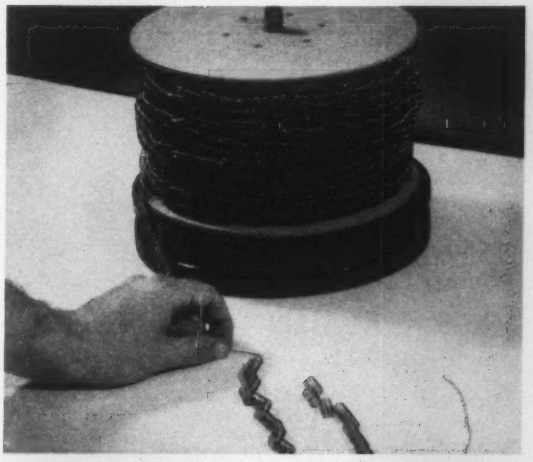
Joint Industry Fall Meetings. The Material Handling Institute Inc., Industrial Truck Association, Monorail Manufacturers Association, Rack Manufacturers' Institute to meet at the Cavalier Club, Virginia Beach, Va. More information is available from Hanson & Shea Inc., One Gateway Center, Pittsburgh 22, Pa.

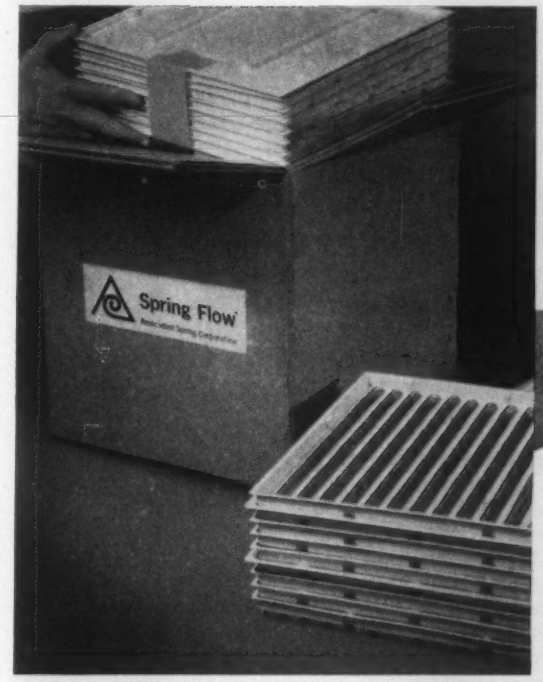
Sept. 12-15—

Society of Automotive Engineers. National farm, construction, and industrial machinery meeting, production forum, and engineering display to be held Milwaukee Auditorium, Milwaukee, Wis. Details are available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

"Using piano rolls for numerical control of our production machines is the invention of the century. Now we can make any product for which there's a song."

Reduce your assembled costs with new Spring-Flow® packaging





. . . more efficient handling, storing, sorting, orienting, feeding, placing of springs for installation

To production planners, Spring-Flow packaging opens up a world of possibilities for assembling A.S.C.-made springs, small stampings, and wire forms into your products easier and faster. It solves many problems caused by intricate shapes, tangling, loss by spoilage; maintains critical tolerances, uniform quality; simplifies inventory control and storage.

At the Production Engineering Show, Sept. 6-16, see this and other spring innovations at

BOOTH 204

To learn how Spring-Flow may solve your problem, contact the nearest A.S.C. Division, or write for Spring-Flow booklet giving additional information.

6004

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Wallace Barnes Steel Division, Bristol, Conn.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
Cleveland Sales Office, Cleveland, Ohio
Chicago Sales Office, Chicago, Ill.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Mattoon, Ill.
Milwaukee Division, Milwaukee, Wis.
Seaboard Pacific Division, Gardena, Calif.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

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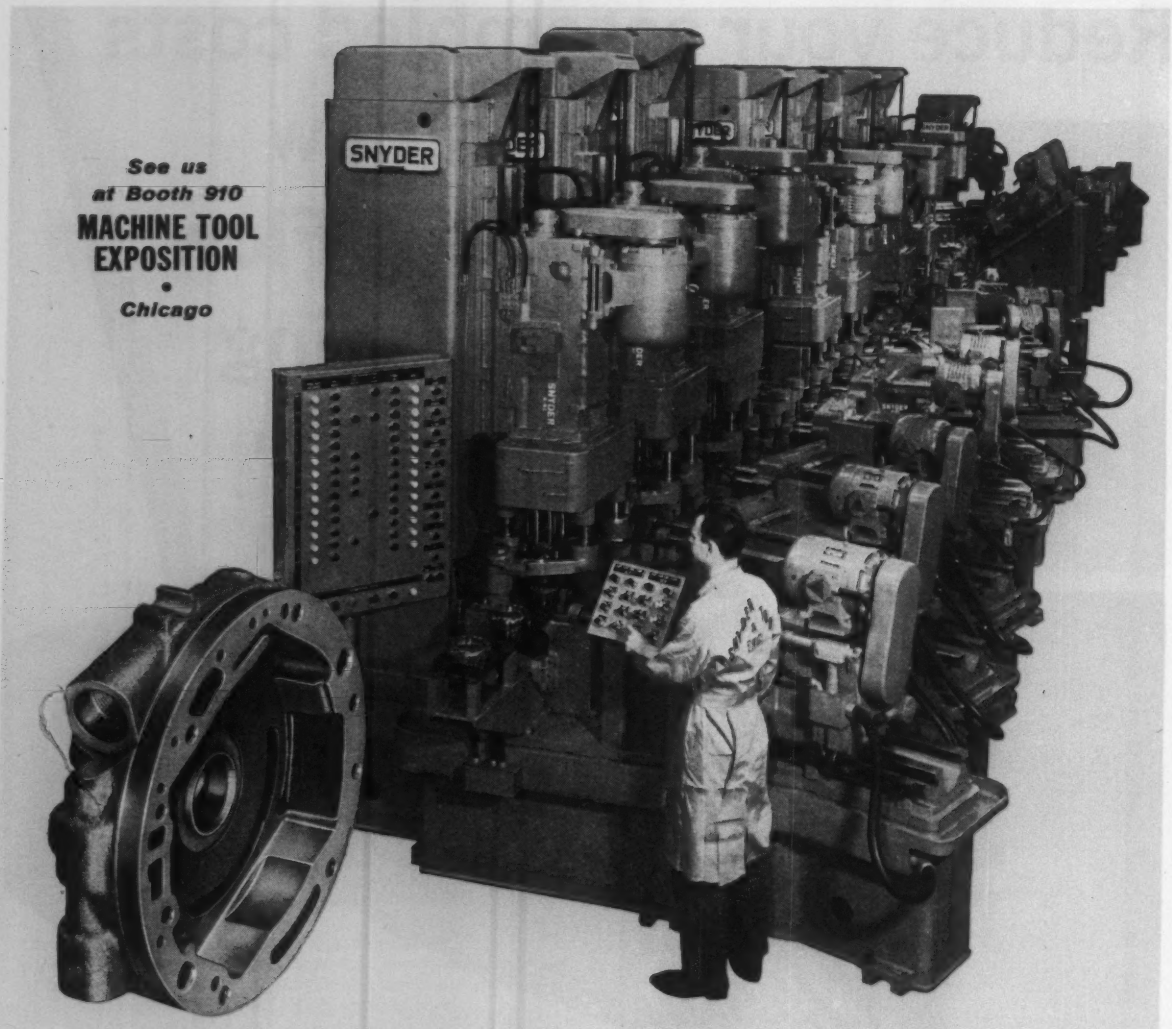


SNYDER BUILDING-BLOCK PRINCIPLE MAKES TRANSFER MACHINES VERSATILE, CONVERTIBLE, THRIFTY

Transfer machines built up on the "building-block" principle are old stuff at Snyder and we've built all kinds of them—including the ones that turn corners and bring the part back to where it started from, processed from half-a-dozen angles, gaged, probed, automatically inspected in process, washed and dried and rejects marked for re-processing. Nothing to it if that's what the job calls for. We call it the Snyder Building-block Principle.

Here's an example of a fairly simple Snyder building-block transfer. This 58 station machine performs 74 operations on an automatic transmission pump body, drilling, reaming, tapping, gaging and probing 180 parts an hour at 100% efficiency. Any or all of its 22 segments can easily be converted to perform comparable operations on other parts. Also, the number of segments can be reduced or increased at any time, as need dictates. Your inquiries are invited.

SNYDER
CORPORATION
(Formerly Snyder Tool & Engineering Company)

3400 E. LAFAYETTE—DETROIT 7, MICHIGAN
Phone: LO 7-0123

Circle 690 on Page 19

By JAMES C. KEEBLER Managing Editor

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Unit A	R	X	R	R	I	R	R	I	R	I	R	I	R	I	R	I
Unit B	R	I	R	R	X	R	R	I	R	I	R	I	R	I	R	I
Unit C	R	I	R	R	I	R	R	X	R	I	R	I	R	I	R	I
Unit D	R	I	R	R	I	R	R	I	R	X	R	I	R	I	R	I
Unit E	R	I	R	R	I	R	R	I	R	I	R	X	R	I	R	I
Unit F	R	I	R	R	I	R	R	I	R	I	R	I	R	X	R	I
Unit G	R	I	R	R	I	R	R	I	R	I	R	I	R	I	R	X
System	R	X	R	R	X	R	R	X	R	X	R	X	R	X	R	X

LEGEND: X = Down for repairs, I = Idle, R = Running

Plot of downtime for hypothetical multistation machine with seven units. It is assumed that historical records on individual units show that each has a downtime efficiency of 90 per cent. The order in which the units go down is not important to the plot, but the assumed nature of the system is that when one unit goes down the others must be idle and the system considered down. Using one hour increments it is necessary to extend the plot for 16 hours in order to fill out the nine-tenths ratio for all units. This shows a system efficiency equal to nine divided by sixteen or 56.2 per cent.

Figure Up Downtime

THIS is surely the age of science. The seat-of-the-pants engineer is fast taking his place in history with the bull-of-the-woods manager. The test driver that checked out shock absorbers by the feel of the ride is now carrying a car full of instruments. The cold age of reason is not only being measured at every turn, but is also being calculated in advance.

Evidence to Show

Alert management expects the manufacturing engineers to accompany their processing and equipment proposals with more than a happy smile and a will to win. Gone are the days when the master mechanic could answer the question, "How do you know this is the best way?" by simply jutting his jaw and saying, "We just *know*."

Trends such as this reflect not only a more cautious management, but also a more enlightened manufacturing engineering profession.

Electronic methods of record keeping have contributed in large measure to the conversion of some of the old-guard to more modern methods of analysis. In the first place much valuable data can be obtained from present performance records of existing machine installations. These data can be used as a basis for planning if they can be presented readily to the manufacturing engineer in a meaningful form that can be manipulated to suit the comparisons required.

In the second place any crystal ball work needed can be done at the level of finer details and be less susceptible to great big errors.

Masterful Intuition

This observer never ceases to be amazed at the accuracy of the intuitive nature of the production executive who has lived with his processing problems for a number of years. Often these men develop a sixth sense that comes up with an impressively concise conclusion in less time than it takes to stack a deck of punched cards. To those of the newer set who are better equipped with mathematical techniques, but carry less experience in matters of production this "dumb-luck" may be looked upon with awe, but does not represent a talent to be mastered. There is a keen awareness that new processes are being developed at such a fast pace as to make accurate cursory assessments increasingly less likely.

Multiple Trouble

One area that invites further study of the problems of applying mathematical data to production situations is that of determining the requirements for in-process storage banks to lessen the effects of downtime on the over-all productive efficiency of a line. When a group of machines are directly linked in series with each dependent upon the preceding machine to supply it with workpieces, the failure or shutdown of any one machine in the line will cause all to be shut down simultaneously.

In planning a modern automated line or transfer machine it is customary to limit the number of stations directly connected, and insert storage banks in the line periodically, so that if a station downstream of the bank goes down, those upstream can continue to operate and feed parts into the bank. If an upstream station is down, the downstream stations draw parts from the bank. In order to accurately plan in advance where such banks should be located and how big they should be, it becomes necessary to estimate the performance of each workstation and apply these data to a determination of the probable performance of various possible groupings of workstations.

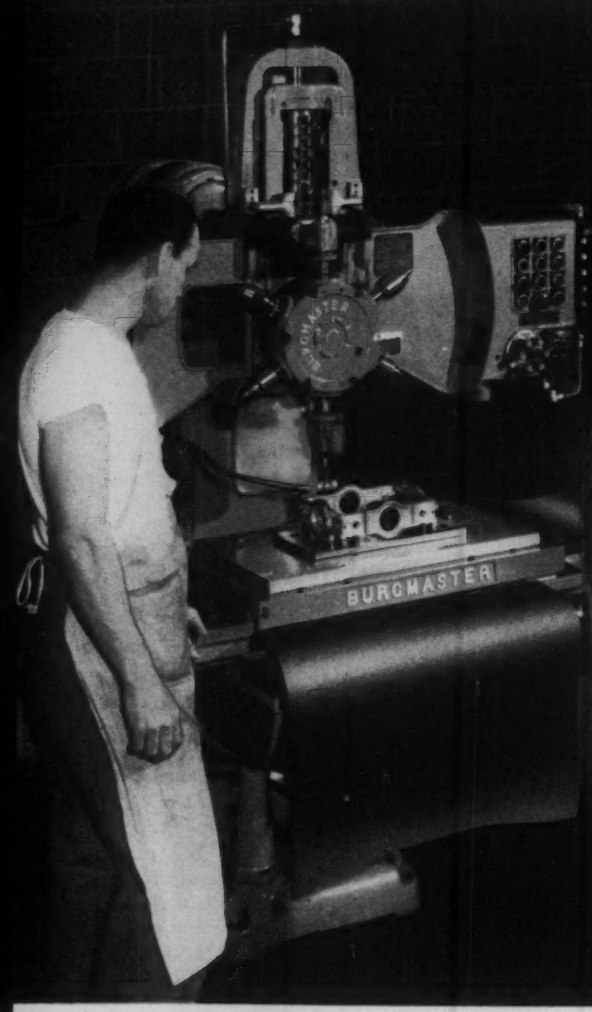
Multiply Trouble

Military electronics scientists have long been concerned with the over-all reliability of systems containing components of varying degrees of reliability, and have worked out mathematical techniques to predict the system results based on known component tests. The basis of the method employed involves multiplying the reliability factors of each component to obtain the reliability of the system.

Some manufacturing men have been quick to adopt this simple arithmetic to grouping workstations in series. Many are the writings that show individual workstation efficiencies multiplied together to get system efficiency. It is often pointed out that such multiplying

PRODUCTION INCREASED UP TO 98%

Burgmaster Tape Controlled



$3260 SAVINGS

$165 COST

TOOL SAVINGS ALONE PAY FOR MACHINE IN LESS THAN 1 YEAR

A production analysis of six typical jobs produced by Mechanical Specialties Co., Los Angeles, California on their Burgmaster Tape Controlled 6-Spindle Turret Drill shows that producton costs have been sharply reduced on diversified job shop work. By comparing the operation of the Burgmaster Machine with conventional drilling methods it was found that average production was increased 98% while a tool savings of $3260 for the six jobs was realized. Lot sizes ranged from 1 to 50 parts.

During the recent 12 month period, over 100 diversified jobs requiring a high degree of precision have been produced on the Burgmaster at this plant. The savings in tooling costs alone in this length of time far exceed the cost of the Tape Controlled Burgmaster.

THE IDEAL MACHINE FOR THE JOB SHOP
— MAXIMUM FLEXIBLE AUTOMATION

Mechanical Specialties says, "Lots of any size are produced more economically on our Tape Controlled Burgmaster Machine — small lots are no problem." This is because tooling costs — and lead time — are greatly reduced. Jigs and complex fixtures are not required. Instead, simple work holding devices and standard clamps are ordinarily used.

Parts are produced faster and to greater precision because all machine functions are controlled by tape, eliminating the human factor. The positioning table locates the work under the turret within ±.001" for each operation. During each turret index, the spindle in the working position automatically shifts to the preselected standard machine settings of speed, feed and depth of cut.

THE MACHINE TOOL

MMT-PE

Booth 840

Exposition - 1960

$3260 TOOL SAVINGS
IN DIVERSIFIED JOB SHOP WORK WITH A

Six-Spindle Turret Drill

(at mechanical specialties co., los angeles)

14 holes include c-drill, drill, c'bore, chamfer and tap. Savings: tooling 7 hrs./75 hrs., machine time: .4 hrs./ 1.8 hrs.

28 holes in 2 setups include c'drill, drill, c'bore, chamfer and tap. Savings: tooling 3 hrs./115 hrs. machine time 1.2 hrs./3.6 hrs.

10 holes in two setups include c'drill, spotface, drill and tap. Savings: tooling 5 hrs./ 90 hrs.

9 holes include c'drill, spotface, drill, tap and bore. Savings: tooling 4 hrs./30 hrs., machine time .7 hrs./ 1.1 hrs.

SIX TYPICAL JOBS SHOW SAVINGS ON TAPE CONTROLLED BURGMASTER COMPARED TO CONVENTIONAL DRILLING METHODS.

50 holes include c'drill, drill, c'bore-chamfer, and bore. Savings: tooling 8 hrs./215 hrs., machine time 1.7 hrs./ 2.8 hrs.

140 holes in 6 setups include c'drill, drill and tap. Savings: tooling 6 hrs./ 120 hrs., machine time 2.3 hrs./4.5 hrs.

PRODUCTION DATA CHART

Part No.	Part Name	BURGMASTER TAPE CONTROL: Program and Punch Tape Hrs.	TOOLS: Hrs.	TOOLS: $	Mach. Time Hrs.	CONVENTIONAL DRILLING: TOOLS: Hrs.	TOOLS: $	Mach. Time Hrs.	No. of Setups	No. of Holes	Operation
1	Valve Body	.5	7	35.00	.4	75	375.00	1.8	1	14	Ctr Dr Dr Ch C'br Tap
2	Hyd Cont. Valve Inlet	3.1	3	15.00	1.2	115	575.00	3.6	2	28	Ctr Dr Dr Ch C'br Tap
3	Missile Component Ring	.8	5	25.00	1.4	90	450.00	1.4	2	10	Ctr Dr SF Dr Tap
4	Ring for Missile	.6	4	20.00	.7	30	150.00	1.1	1	9	Ctr Dr SF Dr Tap Bore
5	Computer Rail	.7	8	40.00	1.7	215	1075.00	2.8	1	50	Ctr Dr Dr CB-CH Bore
6	Gimbal	4.1	6	30.00	2.3	120	600.00	4.5	6	140	Ctr Dr Dr Tap

Write for Bulletin describing Burgmaster 6 and 8 Spindle Tape Controlled Turret Drilling, Tapping and Boring Machines. Forty-minute 16mm sound film showing all Burgmaster Turret Drills in operation is available without charge.

World's Largest Builder of Turret Drilling Machines

"0" Manual Power Index ¼" Capacity

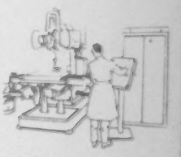
1C Manual Power Index ⅜" Capacity

2B Manual Power Index ¾" Capacity

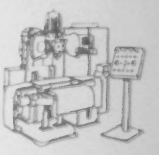
2BR Ram Type Radial Drill ¾" Capacity

2BH Automatic Hydraulic ¾" Capacity

3BH Automatic Hydraulic 1½" Capacity



25AH Automatic Tape Controlled 1¼" Capacity



2BHT-3BHT Automatic Tape Controlled ¾" and 1½" Capacity

BURG TOOL MANUFACTURING COMPANY, INC.

15001 South Figueroa St., Gardena, Calif.
FAculty 1-3510 • DAvis 9-4158

BURGMASTER DIRECT SALES OFFICES: Ridgewood, N. J., 86 North Maple Ave., Gilbert 4-3002 • **Chicago 5, Ill.,** 4908 Lincoln Ave., LOng Beach 1-1178 • **Cleveland 7, Ohio,** 14706 Detroit Ave., ACademy 6-7030 • **Detroit 37, Mich.,** 13730 W. Eight Mile Rd., Lincoln 8-4333 • **Northern California,** JEfferson 7-1650

Plus dealer representatives in other industrial centers.

Circle 691 on Page 19

drops the over-all efficiency in a big hurry. For instance, seven units, each rated at 90 per cent, yield an over-all figure of 47.8 per cent.

If records on a given operation showed that it was down 10 per cent of the time, this combination of seven such operations in transfer machine style might be expected to produce a system that was down more than half the time. Some of the old-guard tell us that this might be good arithmetic, but it doesn't happen that way in their shops.

Trouble with Multiplying

Because we don't believe in flying by the seat of anyone's pants, we did a little downtime plotting to verify this for our own satisfaction. We came up with the suspicion that what's wrong with this simple multiplying method is that it doesn't account for the time a unit is off the line because another unit is being repaired. With respect to the idle unit, this time can neither be counted as downtime nor uptime. Even though the whole system is down, the downtime is chargeable only to the unit that needs repair, and during that period the other units are simply idle.

Such a plot for seven units at 90 per cent each shows the system to be operating nine-sixteenths of the time or 56.2 per cent. This looks better than the 47.8 by the reliability method.

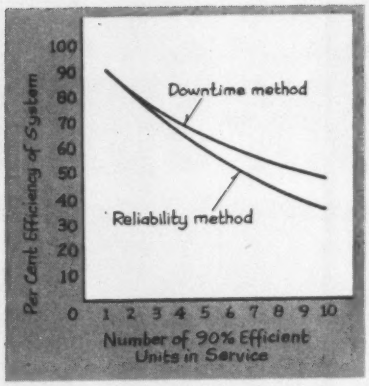
If this theory meant we were applying the wrong equation to the problem, the next challenge was to find the right equation.

New Equation

AUTOMATION's Lee Miller applied his talents to this and came up with the equation in the accompanying box. The difference in results between the two methods is graphically portrayed for systems of one to ten units (each of 90 per cent efficiency) being combined into a series.

It must be recognized that the simple multiplication equation is valid for what it was intended: If the reliability factor used is the probability that a unit will go down, then the product of the factors is the probability that the system will go down. However, if the factor used is downtime efficiency obtained from dividing running time by the sum of running time and downtime, then the simple multiplication equation doesn't apply.

There is reason to believe that the equation derived herewith applies to cases where units of known downtime efficiency are combined into interlocked systems. For those who say that this new curve is on the right side of the graph but it's still not good enough, several things must be pointed out. This method assumes none of the unit downtimes are concurrent. However, if tool changes, repairs, or preventive maintenance adjustments are made on several units concurrently this will improve system efficiency. If the downtime efficiency of the single unit includes downtime for shift changes, personal time for operators, and other time not attributable to the mechanical performance of the machine, these items should be taken out before applying the equation and then figured in again for the combined system after the system efficiency has been calculated.



Who Agrees?

This fascinating numbers game is but a small part of the problem of applying known production data to the design of automated systems. Manufacturing engineers and equipment designers are interested in developing such techniques. Any of our readers with methods or experience to corroborate or refute our conclusions are solicited to submit their comments.

Let t = time units run
a = downtime caused by Unit A
b = downtime caused by Unit B
l = downtime caused by Unit L last of n number of units

Efficiency of Unit A = $E_A = \frac{t}{t+a}$ $\therefore a = \frac{t}{E_A} - t = t\left(\frac{1}{E_A} - 1\right)$

Efficiency of Unit B = $E_B = \frac{t}{t+b}$ $\therefore b = \frac{t}{E_B} - t = t\left(\frac{1}{E_B} - 1\right)$

Efficiency of Unit L = $E_L = \frac{t}{t+l}$ $\therefore l = \frac{t}{E_L} - t = t\left(\frac{1}{E_L} - 1\right)$

Efficiency of System = $E_S = \frac{t}{t+a+b\ldots.+l}$

$$E_S = \frac{t}{t+t\left(\frac{1}{E_A}-1\right)+t\left(\frac{1}{E_B}-1\right)\ldots.+t\left(\frac{t}{E_L}-1\right)}$$

$$= \frac{1}{1+\left(\frac{1}{E_A}-1\right)+\left(\frac{1}{E_B}-1\right)\ldots.+\left(\frac{1}{E_L}-1\right)}$$

$$= \frac{1}{\frac{1}{E_A}+\frac{1}{E_B}\ldots.+\frac{1}{E_L}+1-n} = \frac{1}{\frac{1}{E_A}+\frac{1}{E_B}\ldots.+\frac{1}{E_L}-(n-1)}$$

Example:
Find system efficiency of machine consisting of units having the following individual efficiencies:

$E_A = .87$ $E_B = .90$ $E_C = .92$ $E_D = .85$ $E_E = .85$ $E_F = .90$

Downtime method:

$$E_S = \frac{1}{\frac{1}{E_A}+\frac{1}{E_B}+\frac{1}{E_C}+\frac{1}{E_D}+\frac{1}{E_E}+\frac{1}{E_F}-(n-1)}$$

$$E_S = \frac{1}{\frac{1}{.87}+\frac{1}{.90}+\frac{1}{.92}+\frac{1}{.85}+\frac{1}{.85}+\frac{1}{.90}-(6-1)}$$

$$= \frac{1}{1.14943+1.11111+1.08696+1.17647+1.17647+1.11111-5}$$

$$= \frac{1}{6.81155-5} = \frac{1}{1.81155} = \boxed{.552}$$

Reliability method:

$$E_S = E_A \times E_B \times E_C \times E_D \times E_E \times E_F$$

$$E_S = .87 \times .90 \times .92 \times .85 \times .85 \times .90 = \boxed{.468}$$

Circle 692 on Page 19→

GAYLORD SETS THE STAGE
FOR SMOOTH AUTOMATIC PACKAGING

Plan a happy ending for your automatic packaging.
Buy containers that fit your machinery precisely,
flow through your lines without a stumble or a fluff.

Gaylord produces such containers, with
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3 WAYS YOU CAN KEEP AHEAD OF COMPETITION

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Profit margins aren't getting any better . . . just the opposite. It's no longer a matter of "getting the stuff out". The problem now is making it *better at lower cost.* Advanced gaging—by FEDERAL—can do it. The gaging ideas are proven profit makers. The gages, far from being monsters of automation, are compact, standardized units, realistically designed to provide automatic control or inspection, or both, where it does the most good and at a price that almost *every* manufacturer can afford. And they have reliability . . . the most important single feature of FEDERAL Gaging.

Whether you're big or small in terms of production, *at least one of these gaging arrangements can pay off for you.* It's the truth. Ask us to prove it. Write:

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6398 Eddy Street • Providence 1, Rhode Island

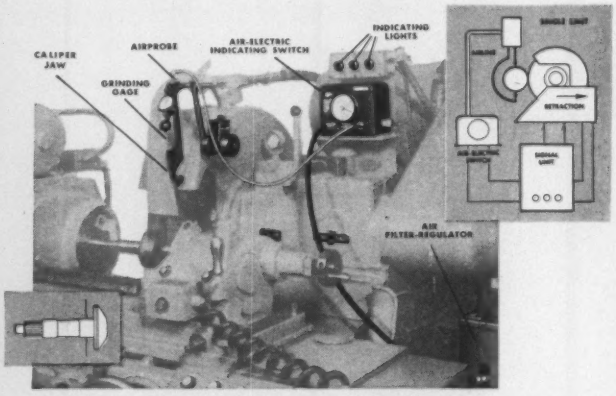
❶ AUTOMATIC CONTROL OF FINISH SIZE

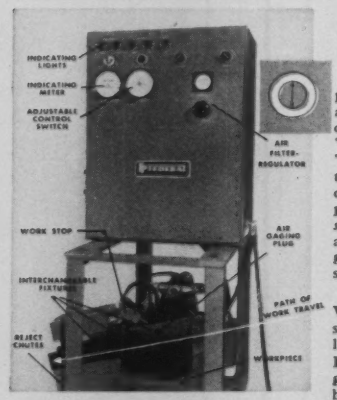
This standardized control gage continuously measures and indicates size of work as it is being ground and automatically causes wheel to retract the instant finish size is reached. Unit can be easily applied in the field to any center type grinder having hydraulically controlled wheel slide.

BENEFITS: Reduces costs — one operator handles two, possibly three grinders performing the same or different operations. Gages pay for themselves within a few months.

Improves quality — even if you have only one grinder, gage is a profit-maker because it eliminates error due to operator inattention or fatigue and also eliminates cost of later inspection.

VARIATIONS: Similar FEDERAL Gages are available through machine tool manufacturers to change wheel feed rate to dwell grind also . . . or to control dressing cycle and finish size on I.D. grinders. When specifying machine tool requirements be sure to include Federal gaging.



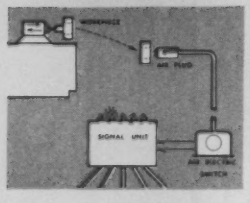


❷ AUTOMATIC 100% INSPECTION

This standardized "post-process" gage inspects every part as it is discharged from the machine and sorts work into "good", "*near*-over", "*near*-under" plus "salvage" and "scrap", indicating the size of each piece. Operator can compensate for drift and piece-to-piece variation *before any scrap parts are produced.* Can be applied to any type I.D. or O.D. grinder, lathe, boring machine or screw machine.

BENEFITS: Lower cost per part. Virtually eliminates scrap by showing trend *before* tolerance limits are reached.

Eliminates inspection errors — gage has 99.8% reliability or better.



VARIATIONS: Federal Gages of similar type are available through machine tool manufacturers to also provide automatic compensation of the machine, either proportionally or by increments, so that drift is corrected without need for operator attention. Be sure to specify Federal Gaging when buying machine tools.

❸ SEMI-AUTOMATIC, MULTIPLE DIMENSION MEASUREMENT

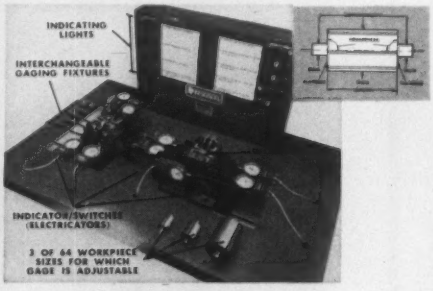
Ideal for small and medium production manufacturers, this gage checks nine dimensions in two stations and is adjustable for 64 sizes! Work is loaded and disposed of manually. Lights show "good", "over" and "under".

BENEFITS: Reduces non-productive costs—inspection time per part is reduced 75%.

Improves quality level. Permits profitable 100% inspection.

Inspection can be performed by less skilled personnel.

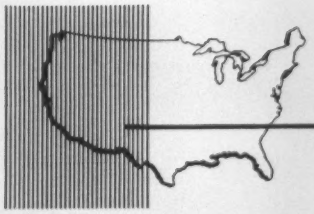
VARIATIONS: Can be designed to provide virtually any combination of dimensional measurements. Unit can incorporate semi-automatic disposal. Other design possibilities up to a completely automated inspection and control gage.


INDICATING LIGHTS
INTERCHANGEABLE GAGING FIXTURES
INDICATOR SWITCHES (ELECTRICATORS)
3 OF 64 WORKPIECE SIZES FOR WHICH GAGE IS ADJUSTABLE

Ask FEDERAL *First*

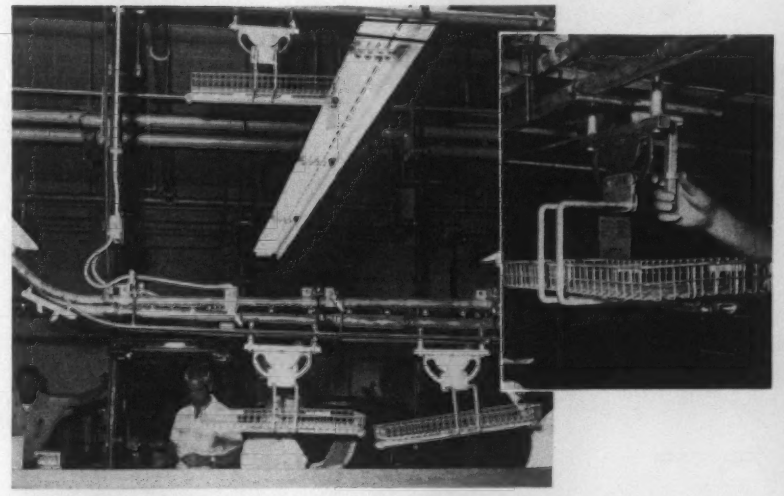
FOR RECOMMENDATIONS IN MODERN GAGES . . .

Dial Indicating, Air, Electric, or Electronic — for Inspecting, Measuring, Sorting, or Automation Gaging



western trends

By PATT PATTERSON
Los Angeles, Calif.



Conveyor system installed at the Times Mirror Press handles manuscript, metal trays of type, and proof pages between departments of the plant. In this view of one of the eight load-unload stations in the system, two self-leveling basket carriers are in the station, and a third carrier is bypassing the station on the overhead main conveyor loop. Each station will hold three carriers. Limit switches prevent additional carriers from entering the station when it is full. Inset shows a closeup view of a carrier and basket. By setting the indicator on the vertical index arm, a carrier can be programmed to enter into one of the eight stations in the system or to continuously circulate on the main conveyor loop.

Handling Between Stations

A MAJOR stumbling block in the automation of many operations is the necessity of providing means for the automatic transfer of materials between two or more stations. Although mechanized material transfer was probably one of the earliest mechanical approaches to automation, the technology of automatic handling has advanced far more slowly than that of controlling repetitive machine operations.

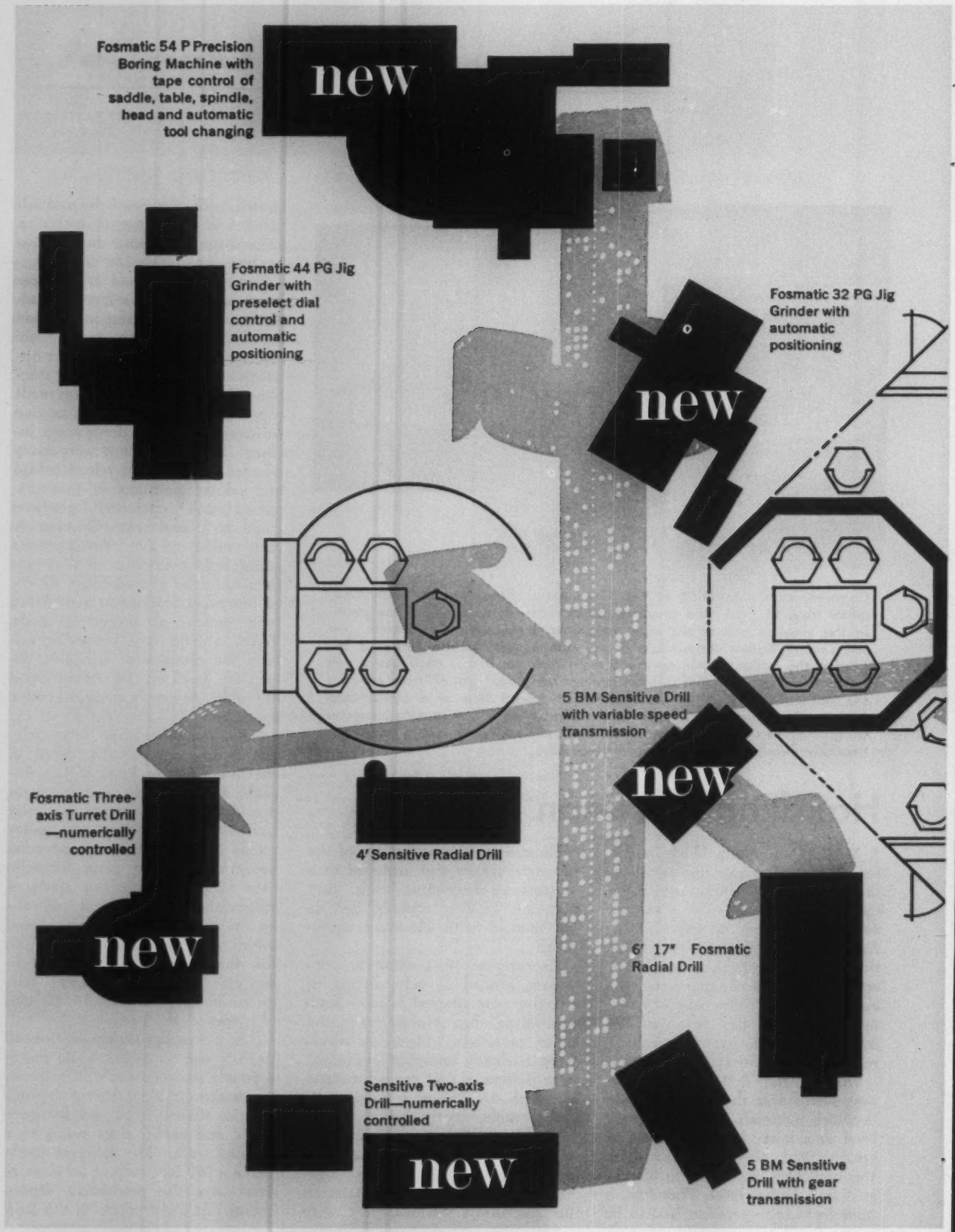
One of the first handling arrangements was the inclined chute in which materials moved from one level to a lower level by means of gravity. With this arrangement, it was obviously impossible to lift objects to a higher level. Therefore, a manufacturing operation had to be sublimated to the limitations of the handling system and arranged in a sequence of descending levels. Any materials moving upward had to be handled with elevating equipment.

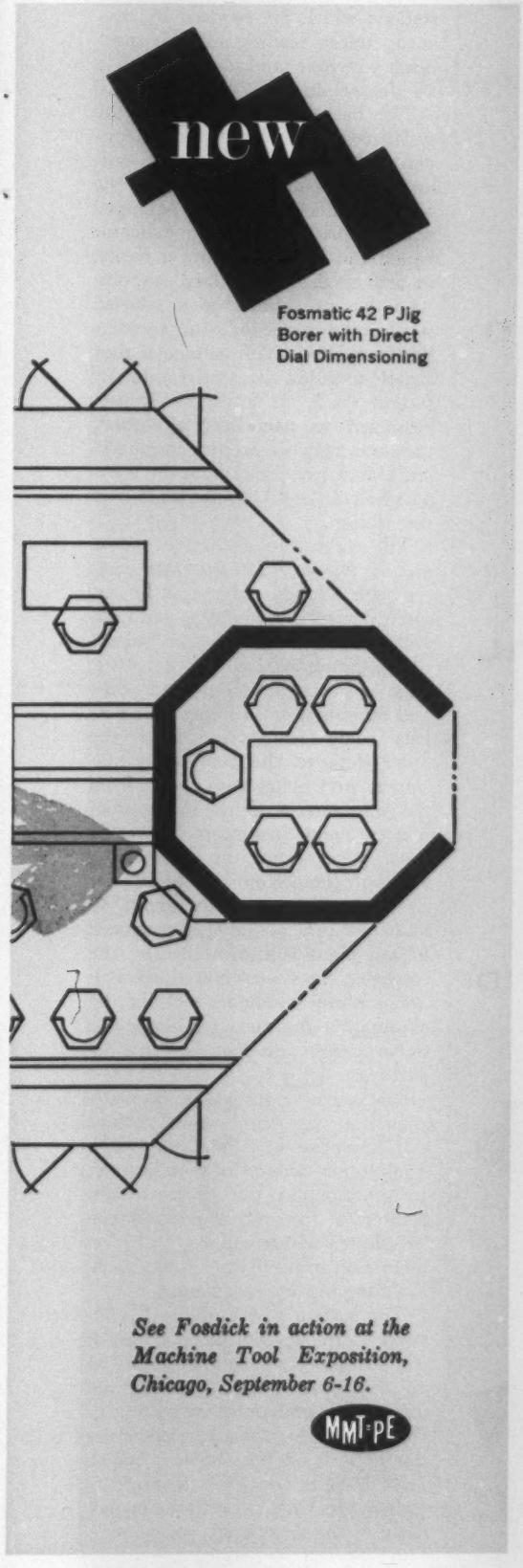
As early as 1830, primitive conveyors, formed of belts sliding in troughs, were adapted to move sawmill refuse, clay, crushed stone, and other materials. These conveyors were gradually improved by adding edge pulleys so that the belt formed a trough, by adding a tough coating of rubber to the belt to reduce abrasion, and by supporting the trough of the belt with spaced idler rolls. However, although belt conveyors were able to carry materials up and down inclines, they were limited in the degree of rise and fall that could be tolerated within a given distance without dumping or tumbling the objects on the belt.

Overhead chain and cable types of conveyors with carriers suspended from the conveying mechanism provided an answer to moving objects from level to level in short distances without dumping or tumbling. These types of conveyors made it possible to carry materials around corners and up and down steep inclines. In addition, they were easily adapted to providing selective load and unload positions so that machines and operating positions could be placed relatively close to each other. Later developments added coding systems so that carriers could be automatically diverted into work stations in accordance with preselected processing steps. Today, a majority of conveying systems for complex or irregular objects are based on the endless chain or cable conveyor overhead drive techniques.

For example, at the large telephone directory printing plant of the Times Mirror Press in Los Angeles, an overhead chain conveyor provides a means for automatically transferring copy, type, and galley proofs between various production departments. The plant occupies over 12½ acres of floor space of which about 96,000 sq ft are used by the production departments and served by the conveyor. In 1959, the firm printed 57 different directories, totaling 6,450,000 telephone books, and used 14,000 tons of paper.

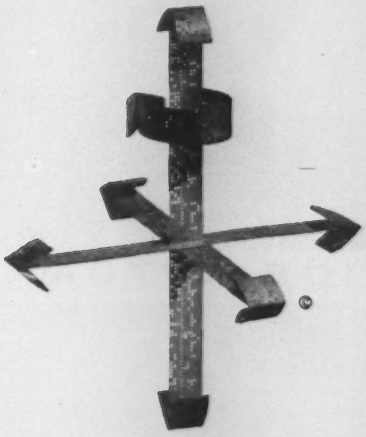
The conveying system services all units in the composing room and is a double track system with suspended basket carriers riding in one tubular shaped track and the drive chain and carrier dogs riding in a parallel track. The conveyor tracks make a 600 foot loop at an elevated level over the production departments. At eight points in the loop,


Fosmatic 54 P Precision Boring Machine with tape control of saddle, table, spindle, head and automatic tool changing
new
Fosmatic 44 PG Jig Grinder with preselect dial control and automatic positioning
Fosmatic 32 PG Jig Grinder with automatic positioning
new
5 BM Sensitive Drill with variable speed transmission
new
Fosmatic Three-axis Turret Drill —numerically controlled
new
4′ Sensitive Radial Drill
6′ 17″ Fosmatic Radial Drill
Sensitive Two-axis Drill—numerically controlled
new
5 BM Sensitive Drill with gear transmission



See Fosdick in action at the Machine Tool Exposition, Chicago, September 6-16.

MMT-PE



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Rest your tired production worries here.

Chasing that elusive last ten-thousandth inch? Here are machines guaranteed to work to that 4th decimal place *on a production basis.* Now Fosmatic Precision Boring Machines are completely automatic, with numerically controlled saddle, table, spindle, head, and tool changer. This is NEW. See them at The Show. Booth 800.

Now famous Moore-Fosdick Jig Grinders have automatic positioning and numerical control. This is NEW. See them at The Show. Booth 800.

Now Fosdick has Numerically Controlled Drilling Machines, versatile and fast. Here's an end to a frozen investment in drill jigs and fixtures. They're NEW. See one at The Show. Booth 800.

Drilling speed like you never saw before, with a battery of tools at the command of a button. It's yours with Fosdick's brand NEW Turret Drill. See it in Booth 800.

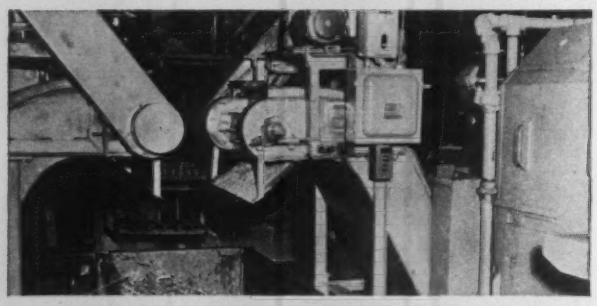
And that isn't all that's new. Come to booth 800 and see for yourself.

Get a proposal from Fosdick.

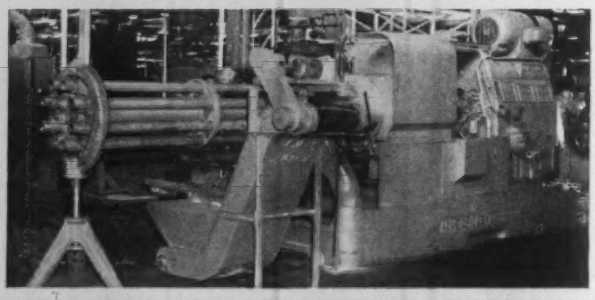
FOSDICK THE FOSDICK MACHINE TOOL COMPANY
Cincinnati 23, Ohio

Circle 694 on Page 19

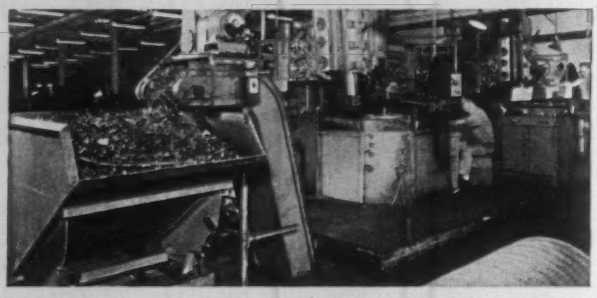
MAY-FRAN CHIP-TOTES



PROVIDE AUTOMATIC AND

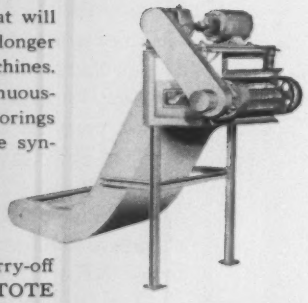


CONTINUOUS SCRAP REMOVAL



FROM ALMOST EVERY TYPE AND SIZE OF MACHINE TOOL

Here is a machine tool accessory that will cut production costs, and permit longer "run" times for your automatic machines. The MAY-FRAN CHIP-TOTE continuously removes the chips, turnings and borings from machines. The conveyor can be synchronized with the metal removing capacity of the machine. Scrap is channeled onto the CHIP-TOTE belt, carried clear of the machine for discharge into tote box or carry-off conveyor system. There is a CHIP-TOTE for every machine tool.



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For complete facts, write today and ask for MF-640.

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the system contains load-unload stations which are serviced by conveyor tracks leading off the overhead conveyor and dropping at a 45 degree angle to the station.

The basket carriers used in the system are suspended from the conveyor and are designed to be self-leveling so as not to dump or spill the contents. Each carrier is equipped with an adjustable indicator which can be set to route a basket to any of the load-unload stations. As a basket approaches a selected station, the preset indicator contacts limit switches which actuate a shoe switch to guide the carrier into the station track. If a carrier is programmed to pass over a station, the limit switches are not contacted, and the carrier is picked up by a bypass belt drive which carries it over the station.

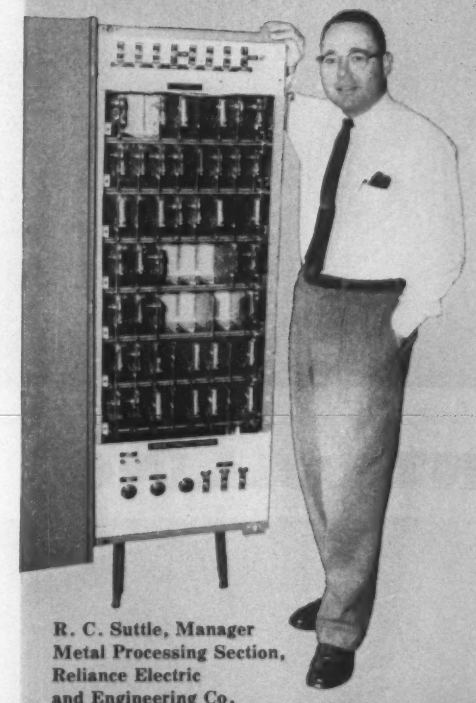
The eight stations in the system are as follows: Linotype or composing machines, order desk for incoming telephone company additions and changes, information advertising, proofroom, classified listing, page corrections, display ad alley and dummies, and commercial. Baskets carry manuscript from the order desk to the composing machines, carry metal trays of type from the composing machines to the proof presses, and transport corrected proof pages from the proofreaders to the composing machines for changes. Although only about 10 to 20 per cent of the type produced in the plant is transported by the conveyor, the system is credited with saving many manhours each day by eliminating the need for employees to carry type and copy between departments.

The conveyor system has been designed so that three more stations can be added at a later date with a minimum amount of modification. In addition to the present eight stations, a free riding position can be selected which will keep a basket in motion around the system without stopping at any station.

The system was built by Chainveyor Corp. A dual drive system is composed of two ½ hp motors in an arrangement which smooths out drive loads and prevents jerking or slowing down when carriers enter the system. Bypass motors which drive V-belts over each station are ¼ hp units which operate independently of the main conveyor drive.

Circle 695 on Page 19

"Reliance V★S drives give American Can accurate system control for high-speed production."



R. C. Suttle, Manager
Metal Processing Section,
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"Precise system control for acceleration, deceleration and shearing is a vital contribution to this cut-to-length tin sheet line. A VSC voltage regulator controls acceleration on the unwind and leveler sections, and provides stepless speed changes. Unwind tension is accurately controlled by a VSR current regulator . . . and the entire drive is powered by Reliance D-c. motors.

"The speed of the shear is matched to the line by photoelectric loop control, maintaining loop position and assuring accuracy.

"Surface defects in the sheet are picked up visually—pin holes electronically. Mechanical gauges check uniform thickness. Rejects are dropped automatically following the shear. Automatic counting cuts handling time as the usable sheets are stacked on pallets."

These lines were developed by the F. J. Littel Machine Company, Chicago, and American Can Company and are installed in Canco Division plants.

Reliance engineers are ready to help you as they have many others, with a sound understanding of system problems and solutions. Consult your Reliance sales engineer . . . or write today for Bulletin Number L-2505 for complete information. D-1640

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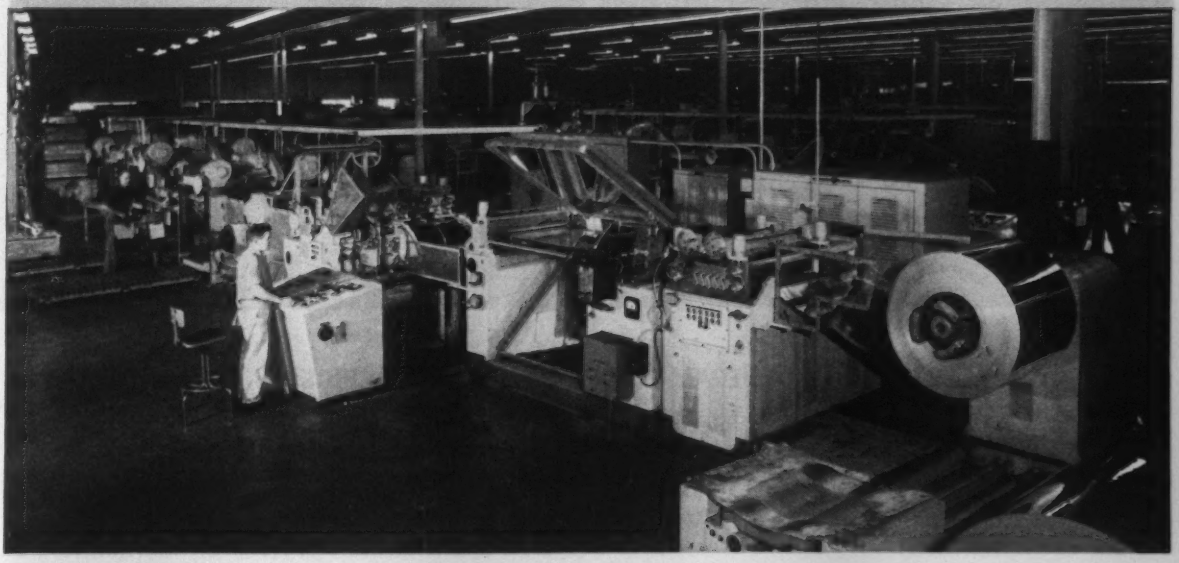
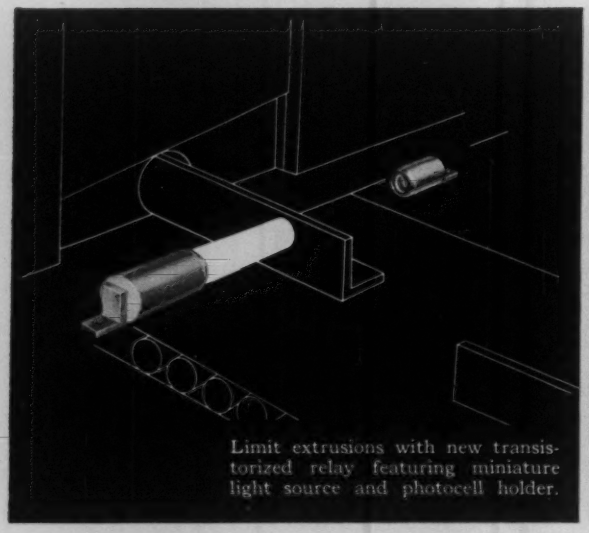


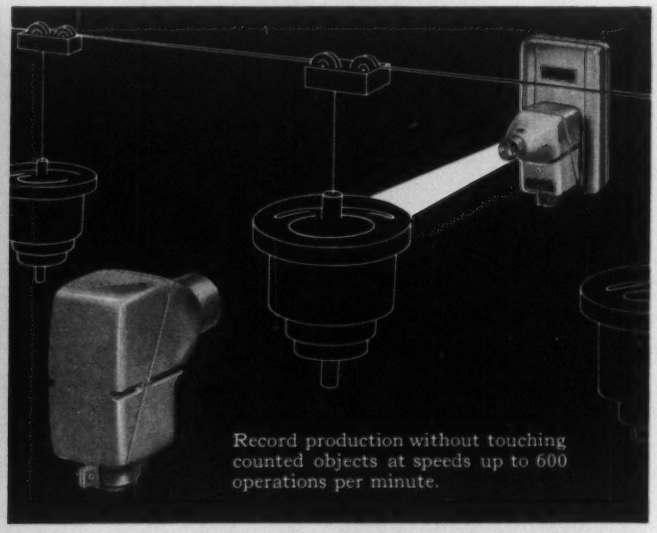
FOR QUALITY . . . PRODUCTIVITY . . . PROFIT . . . MODERNIZE WITH GENERAL ELECTRIC

LIMITING



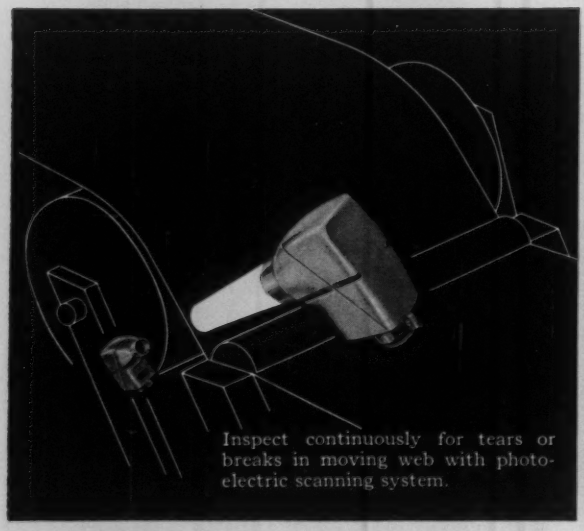
Limit extrusions with new transistorized relay featuring miniature light source and photocell holder.

COUNTING



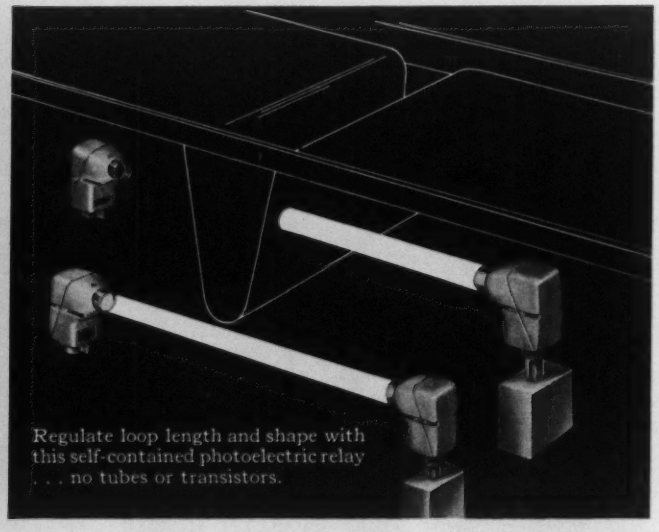
Record production without touching counted objects at speeds up to 600 operations per minute.

DETECTING



Inspect continuously for tears or breaks in moving web with photoelectric scanning system.

CONTROLLING



Regulate loop length and shape with this self-contained photoelectric relay . . . no tubes or transistors.

A COMPLETE LINE OF GENERAL ELECTRIC CONTROL DEVICES

Photoelectric controls
- General-purpose
- High-speed
- Long-distance

Electronic devices
- Timers
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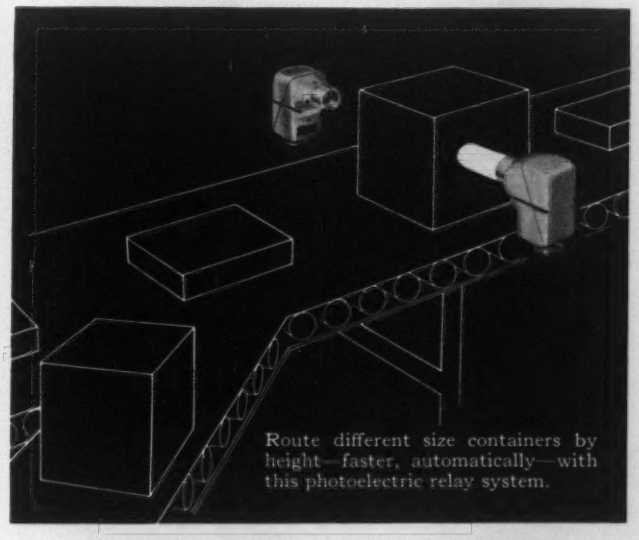
- Voltage-sensitive relays

Photoelectric systems
- Smoke-density indicators
- Side-register controls
- Cut-off register controls

CONTROLS FOR AUTOMATION

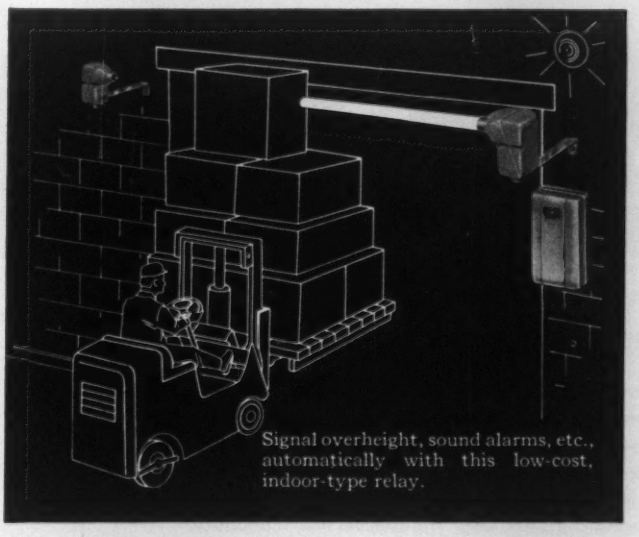
PHOTOELECTRIC CONTROLS

SORTING



Route different size containers by height—faster, automatically—with this photoelectric relay system.

SIGNALLING



Signal overheight, sound alarms, etc., automatically with this low-cost, indoor-type relay.

Switching . . . inspecting . . . counting . . . diverting . . . sorting . . . controlling. These are but a few of the *hundreds* of applications where General Electric photoelectric controls are helping our customers move closer to the benefits of automation—increased productivity, lower costs, higher quality.

Users are finding *new* ways to fit General Electric photoelectric devices into their production processes every day . . . for good reasons: These versatile G-E controls are designed for heavy-duty industrial use. They're easy to install, and require virtually no maintenance. They are highly dependable throughout a long operating life. In fact, General Electric photoelectric controls feature lamps with life expectancy of 10,000 hours—more than a year of round-the-clock operation!

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General Electric photoelectric and electronic devices carry a standard one-year warranty for your protection. And, your order for standard catalog devices is filled immediately from one of six regional warehouses. Also, replacement parts are warehouse-stocked, too, for your convenience and protection.

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Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 697 on Page 19

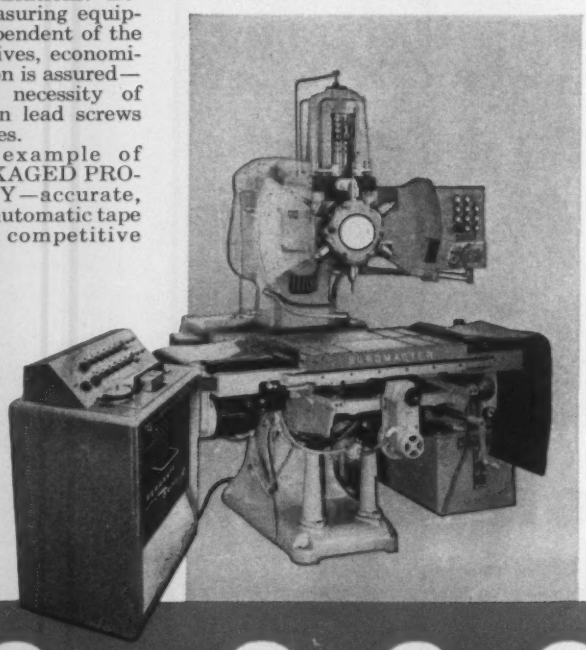
POSITIONING BREAKTHROUGH!

BENDIX ANNOUNCES Numerical Control System for point-to-point work

Long a leader in the numerical contouring field, Bendix has acquired exclusive U. S. sales and service rights on the Ferranti FP-22 numerical POSITIONING control system for machine tools.

The FP-22 is truly the practical answer to the positioning requirements of jig borers, drilling machines, punch presses and other point-to-point applications. Because its measuring equipment is independent of the machine's drives, economical installation is assured—without the necessity of ultra-precision lead screws and gear boxes.

Another example of Bendix PACKAGED PRODUCTIVITY—accurate, dependable, automatic tape control for competitive efficiency.



See Bendix Numerical Control Equipment in booth 530, Production Engineering Show, Navy Pier, Chicago, September 6-16.

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Position display numbers shown here are actual size.

Outstanding features of the Ferranti FP-22 include:

Floating zero—quick and easy set-up—low cost tooling.
Dial input—provides manual operation flexibility.
Continuous position display—available as an option.
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THE Bendix CORPORATION

Circle 698 on Page 19

Numerical Horizons

Keynoting the pioneering production machines developed to operate under numerical control, the cover of our first issue in August 1954 portrayed a numerical control tape in the form of a Mobius band. The intent was to highlight one of the future promising areas of automation and suggest its infinite possibilities.

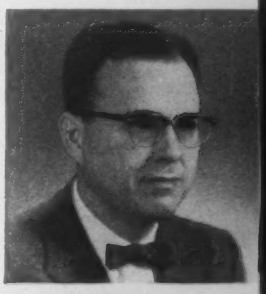
The few years since have brought this development to a state of refinement and application that is impressive in scope. Few had seen the broad-gage advantages and practical opportunities these complex control systems offered in automating batch type operations. Today these systems are available in such variety as to present a rather bewildering problem to interested buyers.

At this critical stage in the evolutionary development of numerical control systems it behooves us to take a careful look at the technological as well as the over-all picture from manufacturing management's viewpoint. This issue presents a fresh, new approach to understanding, selecting, and applying such systems for any suitable manufacturing operation.

Recognizing that systems of infinite variety can be devised, the problem becomes one of just how sophisticated a combination of elements is necessary to provide the most practical answer for any specific application. Here numerical control is presented from the standpoint of each of the characteristic system elements currently used. Evaluation and understanding of each of these fundamental components and the part played by each will provide new insight into expanded practical use.

Most significant in the knowledge derived from application of these principles has been the key fact that numerical control of manufacturing machinery brings management closer to production operations. It provides more effective control over the product, in terms of quality, uniformity, production time, and handling. In addition, there is gained an advantage in reduced lead time, delivery time, and inventory costs. Ultimately the growing appreciation of a more direct path from product specifications to final manufacture will create increasing utilization of the broad principles of this technique.

Machine tools have featured most prominently in this development during recent years but equipment with numerical control is already at work in more than sixteen different kinds of manufacturing operations. There is no longer any question concerning the utility value of these systems, the big question is what kind. Today's horizons in numerical systems are limited only by understanding and ingenuity.



PUBLISHER-EDITOR

AUTOMATION

project 60

NUMERICAL CONTROL

Experience in the last few years has supplied the answers to several recurring questions about numerical controls: Are such controls feasible? The answer is "yes." Are they economical? The answer is "yes." Where can they be used to advantage? The answer is "almost everywhere." Highlighted in this article are the important aspects to guide would-be users who want to know more about this versatile control technique.

By J. H. McRAINEY and L. D. MILLER, Associate Editors

TODAY a multimillion dollar business affecting many diverse industries, numerical controls existed as but ideas and prototype studies in a few laboratories 10 years ago. Indeed, a significant portion of the early machine-tool history of numerical control is reflected in the three machines shown in *Fig.* 1. The pictures are taken from an article, "Controlling Machines With Tape," which appeared in AUTOMATION's first issue, August 1954. Building on the principles proved by these and similar early studies, a general control concept has been perfected which promises to benefit that sizeable part of industry in which general purpose equipment is used to produce a variety of work.

As an indication of the extent to which numerical controls have progressed in but one industry, over 40 manufacturers are expected to be exhibiting more than 100 numerically controlled machine tools in the 1960 National Machine Tool Builders' Exposition; just 5 years ago, four builders exhibited such equipment. To further the appreciation of this all-important control concept, it is the purpose of this article to relate numerical controls to the general industrial picture, to describe important aspects of control systems, and to point out areas where the concept has proved successful.

Considered in a historical perspective, numerical control is part of a general long-term industrial trend of obtaining more efficient and economical production through detailed planning for manufacturing at higher levels within an organization. This trend is based upon the reality that "non-productive" tasks are associated with any operation but that there is a practical advantage to be gained in freeing the operating departments of any tasks which are not compatible with or which interfere with the basic productive effort.

The effects of the trend can be discerned in a variety of forms: Increasing ratio of white-collar workers to blue-collar workers, greater emphasis on data handling, growth of specialized staff functions in manufacturing, and the tendency for the form of equipment to follow more closely the function of equipment. For instance, the modern transfer machine line is a large-sized example. Such production equipment is a logical outgrowth of management planning for large quantities of parts that are to be processed in a similar manner to exacting requirements. With today's advanced state of the art, detailed planning and preparation results in the required equipment with just that capability necessary for the job.

The transfer line is both a good and poor example to illustrate the trend. It is a good example in that it so thoroughly illustrates how handling, control, and the production process can be integrated by preplanning to obtain a superior production system. It is a poor example, in that, as an almost limiting case, it is too easily dismissed as a "special type" of extended-run production equipment. But consider

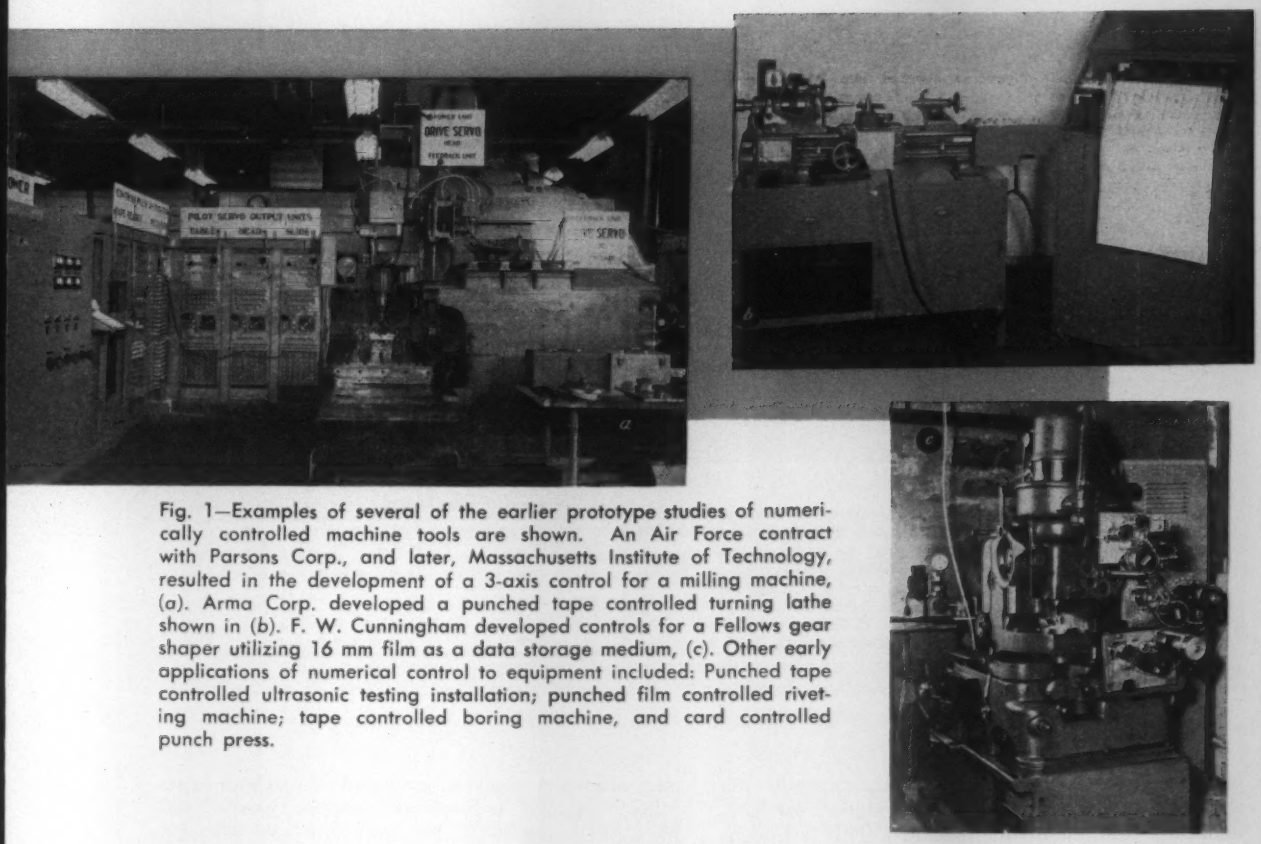


Fig. 1—Examples of several of the earlier prototype studies of numerically controlled machine tools are shown. An Air Force contract with Parsons Corp., and later, Massachusetts Institute of Technology, resulted in the development of a 3-axis control for a milling machine, (*a*). Arma Corp. developed a punched tape controlled turning lathe shown in (*b*). F. W. Cunningham developed controls for a Fellows gear shaper utilizing 16 mm film as a data storage medium, (*c*). Other early applications of numerical control to equipment included: Punched tape controlled ultrasonic testing installation; punched film controlled riveting machine; tape controlled boring machine, and card controlled punch press.

the general effects of extensive preparations ahead of the production operation: Production equipment is operated at planned, optimum levels; unpredictable and limited operator attributes which might adversely affect the productive effort are effectively circumscribed; and demands made on operating personnel are changed, being oriented to more suitable human tasks, such as trouble shooting and overseeing a machine's operation. Translated into specific terms of production, the results embrace such factors as improvements in materials flow, production rates, quality, inventory control, and supervisory control. In a very real sense, management has moved closer to the actual manufacturing operation and obtained a superior production facility by their efforts.

The same basic economic and technical forces which make the transfer line feasible for extended-run production operations confront manufacturers with limited-run production requirements. Confronted with these same problems, limited-run producers must seek the same goals as extended-run producers. However, different tools must be used because of the different production requirements.

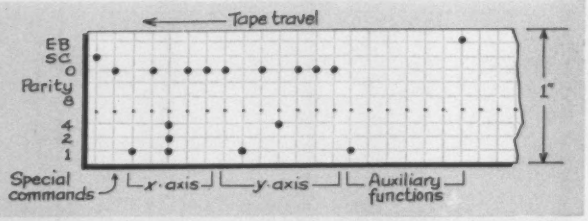
▶ Unique Characteristics

Limited-run production operations are characterized by the use of a given piece of equipment to meet changing processing requirements. Where the frequency of changeover to different jobs is relatively small, manufacturers have sought improved production by such means as dividing complex operations into a multitude of simple ones; arranging equipment to obtain better work flow; providing machines with complex operator aids; and obtaining improved machines with multiple capabilities, higher speed and power ratings, and interlocking and sequencing controls. In numerous processes such techniques have resulted in highly automatic equipment and production lines that compare favorably to the capability of transfer lines.

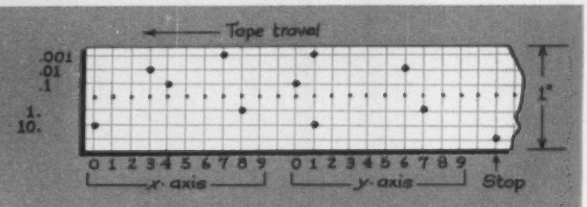
However, the majority of limited-run producers are faced with a frequency of changeover to different jobs—along with various degrees of problems in adjusting and preparing equipment for different uses—that with typical equipment can only be handled by a trained operator at the production machine. The nature of the requirements precludes the use of elaborate means to aid production. The efficiency of the process is that which an operator can obtain from his equipment. And it should be appreciated that the processes themselves can range from those demanding almost no operator skill for manual operation to those requiring a degree of skill either nonexistent or extremely difficult to come by. The economic consequences can be serious.

Though technically "general purpose" machines

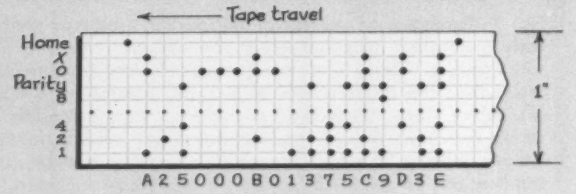
Binary coded decimal information punched into 8-level tape. As illustrated, SC = Start code; Special command 0 = No command; $x = +\ 07.000$; $y = +\ 04.000$; Aux. Function 1 = Use spindle 1; *EB* = End of Block. As applied by Hughes, Industrial Systems Div., tape can be used to control movements in such applications as drilling machines, punching machines, and positioning tables.



Decimal information punched into 6-level tape to control positioning table. As illustrated, $x = 08.437$; $y = 17.061$. As applied originally by Arter Grinding Machine Co. (now Sundstrand Machine Tool Div.), additional information would be written on tape to inform operator of operations to be performed when table positions to a given location.



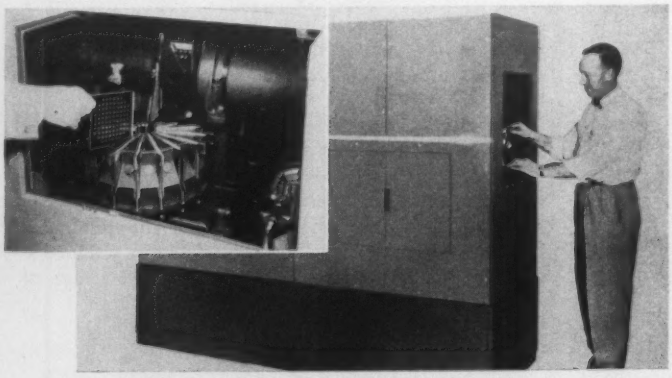
Another example of binary coded decimal information for punched tape used in positioning control. Here numerical data is combined with alphabetical representations that are meaningful to automatic control systems. *HOME* punch identifies blocks of variable lengths; *X* punch indicates alphabetical notations. As applied by General Electric Co., tape represents instructions: A25000 B01375 C9 D3 E. This is interpreted as: $x = 25.000$; $y = 01.375$; C9 = Spindle speed 800 rpm; *D3* = Spindle No. 3; *E* = Coolant On.



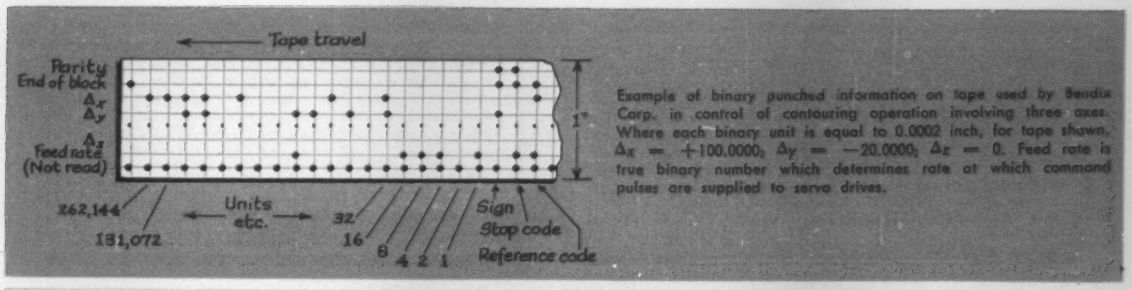
in that changeovers can be made, typically the equipment used by limited-run producers are economically "minimum-run" machines. This is brought about by the fact that there can be an "advantage" to incurring the cost of producing and stocking some number of unneeded parts against possible future requirements rather than incurring the cost of frequent changeovers. Production requirements in a variety of limited-run industries have also evolved to extremes in which efficiency is excessively penalized by the cost of obtaining necessary special-purpose operator aids to make up for machine and operator deficiencies; the non-productive time spent in setting up equipment; or the disproportionately long operating time (as compared to machine capability) required because an operator must "feel" his way through a job. It is apparent that real technical progress so far as limited-run producers are concerned will be measured by how these difficulties are overcome.

Differing from extended-run production where, in general, solving parts handling and orienting type problems has allowed a significant move to a higher plateau of technical performance, limited-run production has benefited most from advances in the state of the art of control and in providing equipment with a number of separate-purpose capabilities. Existing equipment and controls, then, have been

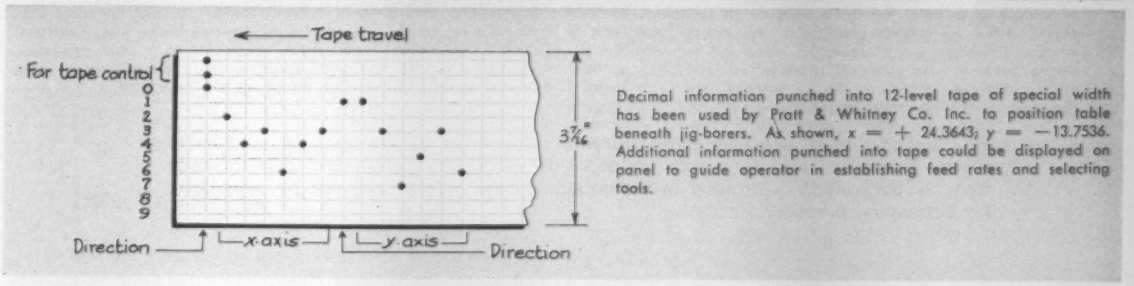
Tape controlled photographic typesetter is built by American Type Founders Co. Inc. Tape commands sequentially select images on type disc to be transferred to film.



Photographic typesetting unit built by Mergenthaler Linotype Co. uses 15-channel punched tape. Tape control sequences operation and selects a specified image from a turret of 18 grid fonts, each bearing 88 images.



Example of binary punched information on tape used by Bendix Corp. in control of contouring operation involving three axes. Where each binary unit is equal to 0.0002 inch, for tape shown, $\Delta x = +100.0000$; $\Delta y = -20.0000$; $\Delta z = 0$. Feed rate is true binary number which determines rate at which command pulses are supplied to servo drives.



Decimal information punched into 12-level tape of special width has been used by Pratt & Whitney Co. Inc. to position table beneath jig-borers. As shown, $x = +24.3643$; $y = -13.7536$. Additional information punched into tape could be displayed on panel to guide operator in establishing feed rates and selecting tools.

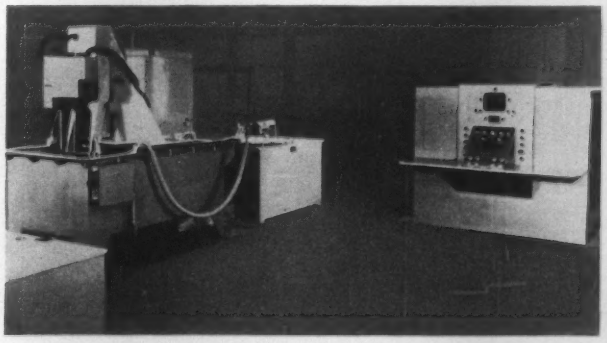
Fig. 2—Samples of punched tapes which have been applied to machine control are diagrammed. In comparing techniques, note that information can be contained on tape in vertical or horizontal manner. Present "standard" tape is 1 inch wide, with 6, 7, or 8 levels of information.

evolving into more sophisticated forms following a sort of main stream of conventional thought and patterns. In some instances this natural evolution has resulted in extremely flexible, automatic equipment which an operator can easily direct by setting control dials, repositioning limit-switch actuators, changing cams, etc.

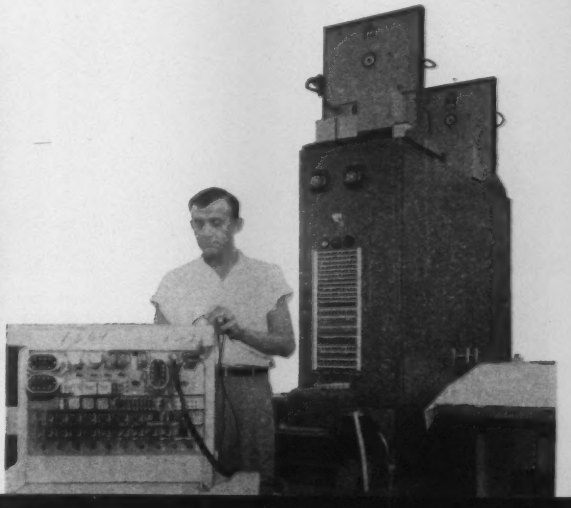
What Is Numerical Control?

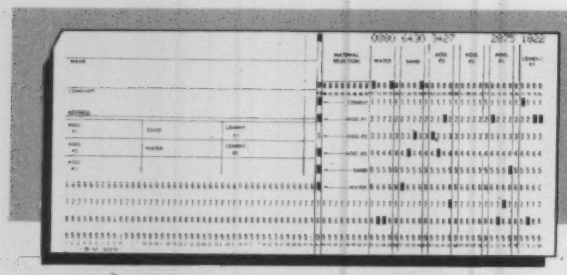
It is in this sort of climate that numerical control came into existence several years ago, primarily forced into being as a result of the government sponsoring a research program into the particular problem of controlling special milling machines, needed in airframe production, and as a result of procuring a sizeable number of such machines. The over-all effect was a leap forward in general control technology. Many existing control forms were allied in some ways to the unusual numerical controls, but in general, a gap in techniques was created. As evidenced by the activities in a broad range of industries, 1960 can be accepted as the date that marks a general bridging of the gap between the "normal" and "unusual." There are now enough trees to make a forest, and background enough to enable the real forest to be described.

Ultrasonic inspection machine developed by Sperry Products Inc. is programmed by punched tape. Scanning head of the machine is stepped to sequential cycle positions on signal from the tape control.

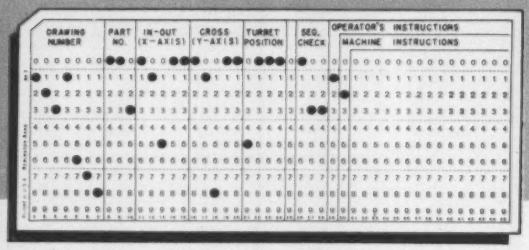


Telephone relay circuits are tested under tape control in this equipment built by Western Electric Co. Inc. Units with as many as 97 terminals are automatically switched on and off 40 test circuits.





Business-type card (IBM) has been adapted to control of concrete batching system by Peerless Electric Co. and Heltzel Steel Form & Iron Co. Following control operation, card can be used for accounting purposes and space is provided for additional punches. Decimal value of desired weights is punched into card; material selection field identifies items that are to be batched.

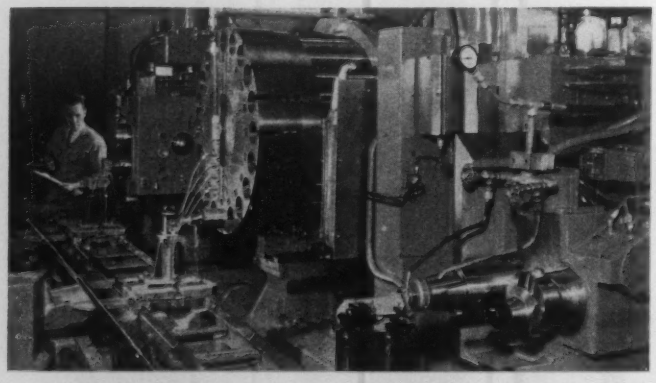


Business-type card (Remington Rand) can be used for numerical control of machine tool. As adapted by General Electric Co., illustrated card form controls turret punch press. Standard card processing equipment is used for punching and sorting. Decimal form of data permits operator to read information directly from card.

Fig. 3—Samples of punched cards illustrate adapability of this type of medium to control purposes. Use of existing business-type cards for control, and decimal code form, is particularly warranted in integrated systems where card can be used later for accounting purposes.

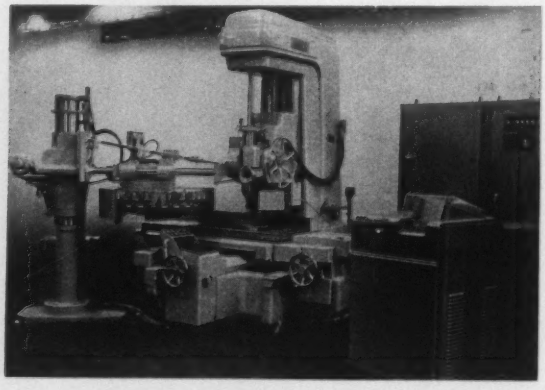
Numerical control embraces more than control of machine tools by numbers—testing, batching, inspection, and assembly are but a few of the other areas where numerical controls are applied. Numerical control is not limited to systems involving feedback—open loop systems have been devised. Numerical control does not necessarily require electronic circuits—for example, a system employing only pneumatic and hydraulic elements is in the prototype stage. Numerical control is not bound to employ calculated numerical data—models can be traced or measured for the preparation of control tapes. Numerical control is not limited to the use of magnetic tape, punched cards, or punched tape —a leading manufacturer of numerical controls offers decade switches and telephone-type dials as an input form. In short, if an appreciation is to be reached, numerical control cannot be simply defined in terms of the particular equipment to which it is applied nor in terms of particular components used in systems.

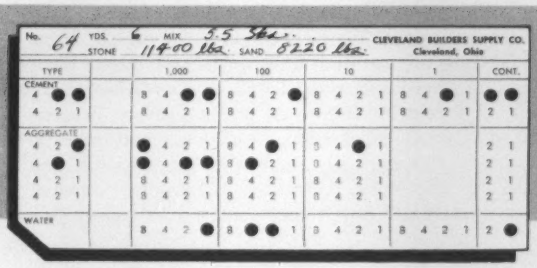
If a definition must be made, numerical control can be defined as a form of control in which automatic equipment is directly controlled by means of a portable media containing preplanned operating instructions, typically in numerical form. However, it must be realized that, essentially, numerical control encompasses a broad range of situations in which the primary functions of automatically operating equipment are capable of being preplanned in sufficient detail, organized, and described in an unequivocal form suitable for immediate and/or direct use by the equipment. As a frame of reference, comparison should be made between the approach of extended-run producers—in which management defines a pattern of operations by detailing the design of the equipment—and limited-run producers using numerical control—in which management defines a pattern of operations by detailing equipment input instructions. In both cases, management obtains improved production by, in effect, moving closer to the manufacturing operation.



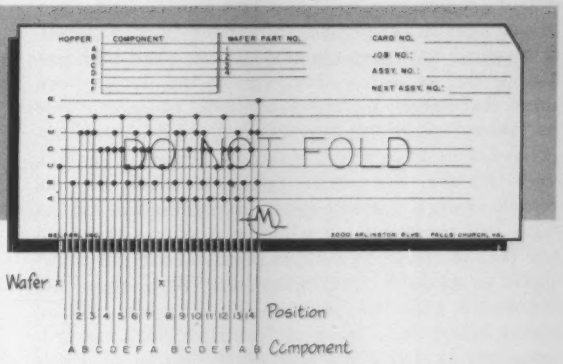
Transfer machine operated under control of punched tapes uses three machining units, selects desired one of twenty spindles on one machining unit, and automatically adjusts bore sizes on another unit. Controls for this prototype equipment were built by Hughes, Industrial Systems Div.; the machine tools by Kearney & Trecker Corp.

Card controlled jig borer was developed by Fosdick Machine Tool Co. and International Business Machines Corp. Besides automatically cycling and positioning the workpiece, this machine selects and changes its tools under card instructions.





Plastic card that programs automatic concrete batching system utilizes binary decimal code (8421). Developed by Fairbanks, Morse & Co. in collaboration with Butler Bin Co., system can weigh out batches containing as many as two out of three cements, up to four of six aggregates, required water, and special additives.



Special card is used in assembly operation involving insertion of electronic components into wafer boards. Designed by Melpar Inc., card selects desired wafer from group of four; establishes position of wafer; and selects component from group of six. From one to seven components can be automatically assembled to each wafer.

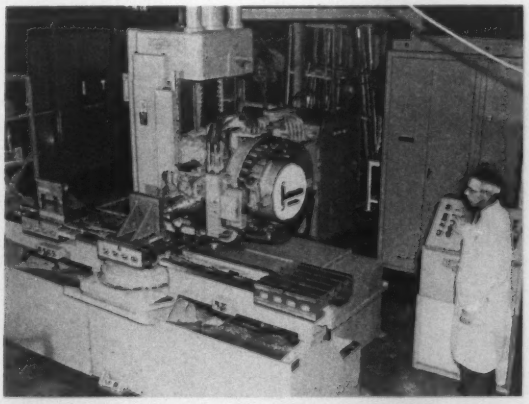
Data Preparation

If management is to move closer to the manufacturing operation by specifying detailed operating instructions in numerical form, various skills which are presently focused at the equipment obviously must be available at some higher point in the organization. And the skills must be available in such detail and form as to permit them to be specified in an unambiguous manner.

Early writings, in contemplating this requirement, tended to overemphasize the problem aspects of data preparation. Certainly some difficulties exist in reducing hitherto general or empirical knowledge to precise, numerical form. Experience, however, has shown that it is an error to consider all data preparation for numerical control as a uniformly severe problem for all applications. The design of control systems might be considered to be uniformly complicated—but a well thought-out control system, in effect, organizes the data preparation problem and permits routines to be established.

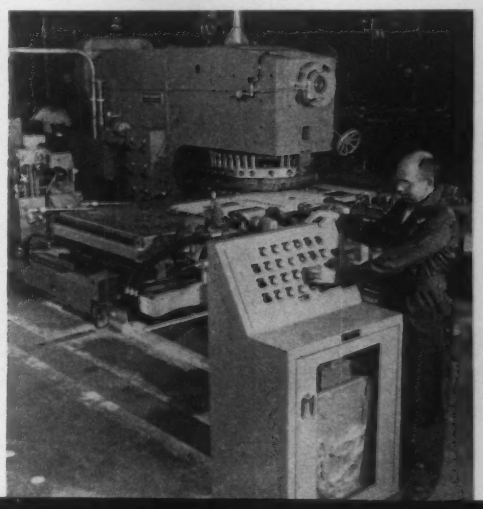
Data preparation varies from schemes that are, on the whole, simpler than present manual systems to schemes that are indeed complex, requiring the use of a computer in preparing machine instructions. For example, programming a batch-weighing operation can be as simple as specifying certain products from an available group and indicating the desired weights. A single code number punched in a given position can be used to designate the desired product, and a series of decimal or easily-read coded numbers can be used to designate weights. In programming an assembly operation, the problem is one of selecting given components in the desired sequence and orienting a part to receive the components.

A rolling operation program involves such data as specifying a series of roll openings, mill speed, direction of rolling, and adjustment of various auxiliary devices, such as scale breakers and sprays. In testing operations, such as might be applied to electronic and electrical assemblies, programming can involve electrical inspection—in which correctness of connections is tested—and electrical evaluations—in which static and dynamic circuit operations are tested. The problem is one of specifying particular



Tools are automatically selected and changed on this horizontal spindle machine built by Kearney & Trecker Corp. Punched tape control manufactured by General Electric Co. also determines motions along three axes, feeds, speeds, and workpiece transfer.

This 100-ton turret punch press built by Wiedemann Machine Co. uses a General Electric Co. tape control system. Punch and die turrets are indexed to present one of 36 tool sets to working position, workpiece is positioned, and machine is automatically cycled.



circuit connections, applying test signals, and comparing circuit responses to pre-established levels.

Machine tool programming is concerned with detailing the sequence of operations involving given tools and specifying the magnitude of controllable variables, typically motion in small increments. Complexity of programming operations hinges, in general, upon whether the process is one in which the tool travels over a variable path in continuous contact with the workpiece, or whether it is one in which the tool is moved to various points about the workpiece to perform spot operations. Both types are concerned with the positioning of a given tool in space. However, a mass of repetitive calculations is necessary to define the path of the center of a tool along two or more axes such that its cutting edge machines a desired contour. It is in this type operation, of course, that a computer proves so valuable. For cutting tools such as in lathe work, the problem is somewhat simplified when cuts are made parallel to a machine axis or at some constant angular relationship to an axis.

Point-to-point operations are concerned with accurately establishing two co-ordinates that define the desired position of a given tool's center; the path actually traveled by the tool in reaching the desired points is of concern only so far as interference with projections and holding fixtures is concerned. As a comparison of the differences between the two types of machine tool control, developing a program for a contour machining operation might require 3 to 4 days; developing a program for a point-to-point machining operation requires but a few hours.

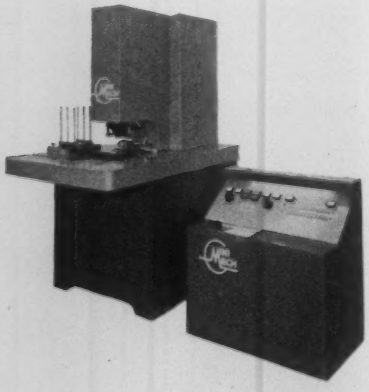
▶ Reorientation Is Required

Whatever the process being controlled, in the majority of instances the basic data required are those normally available somewhere in the present system. Thus, numerical control does not necessarily require new data as much as reorientation and new procedures to make the data available at a single place—the planning office.

This appears to be particularly true in the case of planning for machine tool operations, where pertinent information is typically the scattered responsibility of industrial engineers, tool engineers, process planners, shop supervision, operators, and quality inspectors. Numerically controlled operations, as much as manually controlled operations, depend upon economical and logical sequencing of operations for efficiency; knowledge of equipment capabilities and good machining practices are even more important to the machine programmer in that operators and shop supervision can no longer be counted on to fill in the voids of spotty planning.

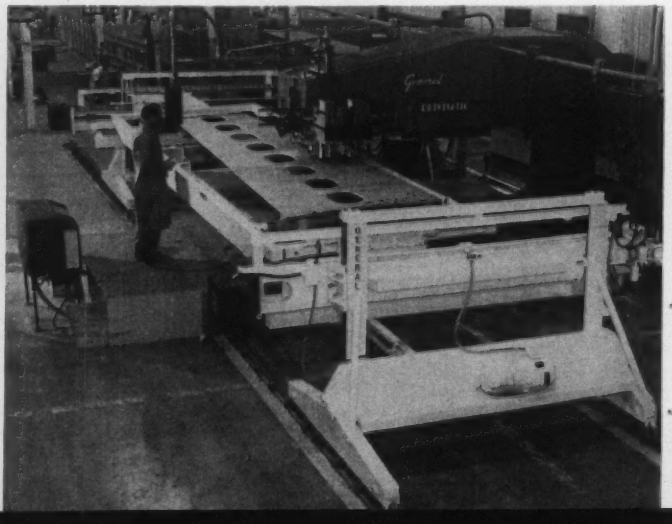
Much of what has been said regarding machine tool systems implies the use of calculated data in planning motion instructions. In some instances, such as planning for a two-dimensional cam whose profile can be described by a mathematical formula, it is feasible to prepare control data without ever going through the drawing stage. Some observers have extrapolated from these special cases, reaching the conclusion that computers could be fed physical design requirements and economic factors, and would automatically create an optimum design with a machine control tape as a byproduct. The possibility is fairly remote that such a technique can be expanded to cover machining operations in general. This is not to say that computers cannot be used in unique ways. One manufacturer has reported an interesting use of a computer in point-to-point data preparation in which computer routines locate bolt-circle holes when given one hole location, the diameter of the circle, and number of holes desired.

However, the importance of calculated data should not be overemphasized. To do so is an injustice to the flexibility of the numerical control concept. Calculated data are used in preparing control instructions, not because it is the only way, but because it is the most accurate way. Where accuracy requirements permit, a control tape can be prepared by tracing a model with a stylus whose motions are recorded; control data can be created by measuring a model; and in establishing point-to-point control



Assembly machine controlled by punched cards selects components from 24 magazines, automatically feeds, inserts, and solders them in predetermined locations on printed circuit boards. Prototype unit shown was built by Melpar Inc.

Riveting machine built by General Electro-Mechanical Corp. is controlled by holes punched in 35 mm film during a setup run. Aircraft panels are positioned and sequential operations drill, insert rivet slugs, upset, and mill flush automatically.



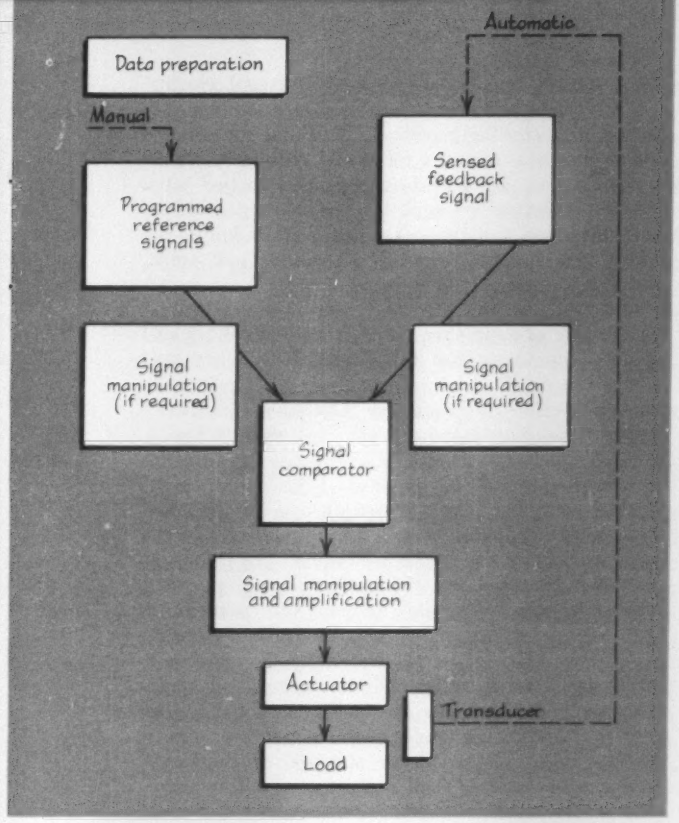


Fig. 4—Typical feedback block diagram for an error-controlled positioning system has been rearranged to emphasize the general signal comparison aspects of such systems. Just as various means can be used to feed command data into the system, a variety of transducers are available to provide feedback signals.

data, a stylus can be moved over an enlarged layout, pausing at desired locations to establish both positions and sequence of operations. In short, part of the function of planning for efficient operations is to ensure that planning itself is accomplished efficiently—and typically the simpler method contributes to the desired efficiency.

Achieving efficiency in planning a machine tool program is of major concern in the case of contouring operations. Computer manufacturers, control system manufacturers, and users are active in searching for improved techniques. The general approach is to provide a computer with the internal capability of accepting general statements and translating the statements into specific and detailed machine tool paths in recorded form. In other cases, special solutions to a previous problem are made available to a computer in solving subsequent problems. The result is that a programmer's task is considerably eased, being able to call upon a computer to accomplish a sizeable amount of work in specifying a tool's path with a minimum of detailed effort. The ideal situation would be one in which no computer is required, and the stated goal of one control manufacturer is to develop a contouring control system which would require programming techniques on the order of complexity associated with point-to-point programming.

Details Are Critical

Undoubtedly, the really new requirement for all types of numerical control is that the planning be exact to the most minute detail. To that end, planning can be more effective if procedures are changed to reflect the requirements of handling a mass of data. For instance, dimensioning a drawing by referencing from a base point can both speed planning and help eliminate errors. Special machining sketches can aid in visualizing the job to be done. A planning sheet form is required that by its subdivisions insures that all pertinent information will be considered, and that by its arrangement simplifies the task of transcribing the data to a storage medium by clerical help. Considering the

Automatic wiring machine manufactured by Gardner-Denver Co. makes solderless wrapped connections at both ends of wires on selected terminals. Card controlled unit moves two wire wrapping bits to predetermined terminal locations and cycles automatically.

Turret drilling machine built by Burg Tool Mfg. Co. Inc. has punched tape control by Hughes, Industrial Systems Div. Desired one of six spindles is indexed to working position and the workpiece positioned by the control system as part of an automatic cycle.

possibility of creating errors in handling a mass of numerical and alphabetical notations, it is not at all surprising that control manufacturers stress the use of well designed planning worksheets and attribute so much to their use.

Transcribing data from the planning form to the storage medium that will be used by the machine is a straightforward clerical operation. Reflecting the simplicity of the task, and the absolute importance of correctness, a typical practice is to transcribe the data twice and compare the two results. There is always the possibility of a stray error occurring in transcribing data, but the probability is small that such an error will be repeated in two different transcriptions. There is another practical aspect to this procedure in that typically a second copy of the machine instructions is required for file purposes.

▶ Various Storage Techniques

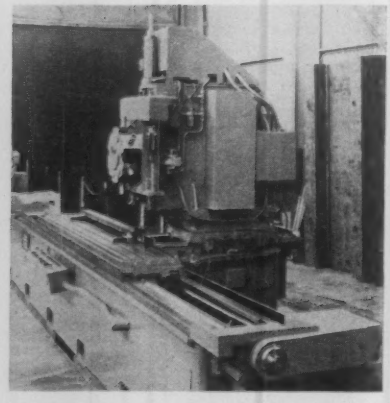
Three major types of media are used for storage of machine instructions: Magnetic tape, punched tape, and punched cards. Magnetic tape is available in a variety of qualities and in various widths (¼ inch to 15 inches). Recording techniques permit a high data storage density, and information can be placed on and read from magnetic tapes traveling at high speeds. As a result, amazingly large quantities of data can be handled over a short period of time. Of particular interest, a relatively large number of parallel tracks (channels, levels) are available on tapes of reasonable widths. For example, a 1-inch width can contain 14 separate tracks on which signals can be recorded. Magnetic tape is extensively used in the data processing and communications industry and its use in control applications is an outgrowth of advances made in those two areas.

Punched tape also has a history primarily rooted in the communications and data processing industries, but there are examples of early use in equipment control applications. Straight-forward electromechanical techniques can be used in handling, preparing, and reading punched tapes, and the concept has been easily adapted to special requirements. As a result, there are a wide variety of punched tapes in use—differing in such aspects as tape widths, hole locations, number of holes placed across the width, how indexed, method of reading, how coded, etc., *Fig.* 2.

However, the existence of a well-developed industry capable of supplying efficient tape punching and reading equipment has influenced the picture, and a recommended standard based on a 1-inch wide tape has been prepared by Electronic Industries Association. The standard provides that either 6, 7, or 8 levels (number of holes across the width) of information will be recorded. With certain commercial equipment, tape punching can be combined with a typing operation and a readable copy of the information on the tape is obtained for filing or checking purposes. All things considered, punched tape appears to be the most popular storage medium.

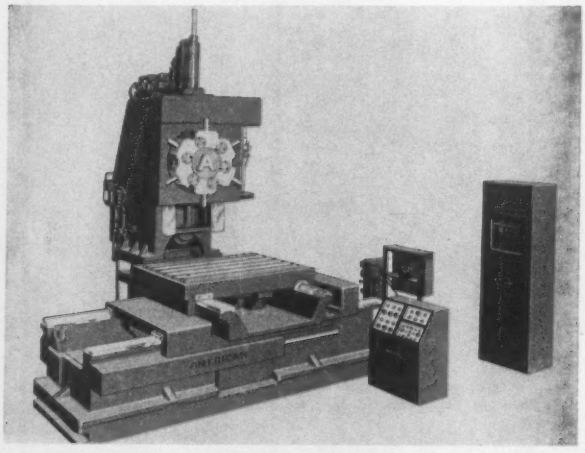
A variety of techniques can be used in sensing the information punched into tape. For example, mechanical feelers, photoelectric means, and sensitive pneumatic elements are employed. Tape can be read a "line" at a time as it is indexed past a reading point, or successive sections, or blocks, of tape can be indexed into position and all information in the block read simultaneously. Block readers capable of handling sections of 8-level tape containing up to 36 lines can be obtained.

The use of punched cards is a well-developed method of storing data for subsequent processing, as is evidenced by the great number of office-type data processing systems. With techniques developed for data processing applications, cards can be handled and read at very rapid rates. The size of card used in these applications permits a large number of separate holes to be punched, but typical coding methods are concerned with the ability of an operator to read the punched code. This provision is obtained at some sacrifice of information storage densi-



Six-spindle turret drill manufactured by Avey Div., Motch & Merryweather Machinery Co., has tape control to select spindles, position workpiece, and determine cycle. The punched tape control was built by Control Instrument Div., Warner & Swasey Co.

Turret type drilling machine built by American Tool Works Co. has punched tape control system manufactured by Sperry Gyroscope Co. of Canada Ltd. Tape commands control machine cycles and the two-axis positioning table.



ty. Availability of existing punching and reading equipment enters into the consideration, but one is not constrained to use business type codes. Some industrial users have found it expedient to adapt the business-type cards to their special requirements because of the basic characteristic of being able to simultaneously read out a large amount of stored data, *Fig.* 3. A number of special card sizes, along with associated punching and reading equipment, have also been developed. Cards are used for all types of control, including contouring, but in particular they appear to be suited for processes requiring a regulating form of control.

Use of a storage medium, of course, provides a means for introducing input instructions in an automatic manner. Most control designs also provide for a semiautomatic mode of operation under the control of an operator. Desired input instructions are entered into the control circuits by means of pushbuttons, decade switches, etc. The use of these forms of manual input is based upon the realization that some jobs for a given piece of equipment might be so simple or of such an experimental nature that preparing a complete stored program would be wasteful of time. Many controls allow the operator to override programmed instructions in several respects, particularly as regards speed and feed rates. Giving the operator a means to also control positioning makes the equipment truly general-purpose.

To some, the inclusion of manual controls is an aberration that nullifies the concept of numerical control. If one is concerned that an operator might indiscriminately alter a well-planned program then it should be a simple matter to lock out the operator panel when its use is not in order. The advantages of having the semiautomatic mode of operation are worthy of careful consideration by potential users.

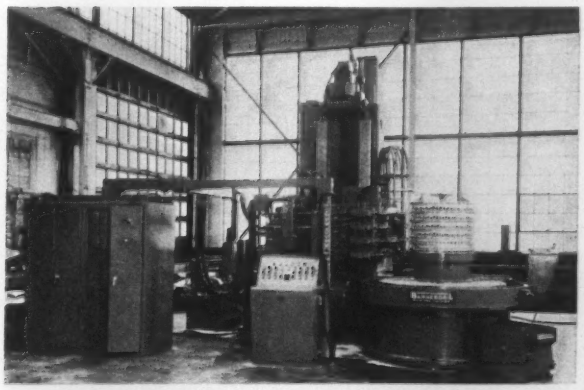
The Matter of Compatibility

A great number of factors enter into the decision as to what type of medium to use in a given case: Reading time; machine cycle time; probability of change in instructions; ease of making corrections; technique required in coding information; ease of reading encoded data by operator; possibility of further use, as in accounting system; etc.

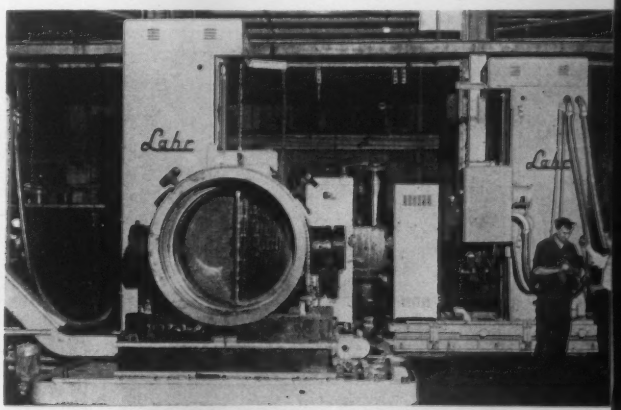
However, it should be appreciated that the decision as to type of medium is one that primarily lies with the control designer and equipment manufacturer. In some applications, the storage medium is an integral part of the control system and, in effect, no option is available to the end user of the equipment. For instance, a particular storage medium might have been chosen by the control designer because it makes a great deal of information available simultaneously to the system. This eliminates requirements for electrical storage of data by circuits and also simplifies the problem of co-ordinating various signals.

Despite this type of limitation, the user is concerned with the medium used since it can affect the first cost of the equipment, and more importantly, the day-to-day programming and operating costs. Perhaps the most important consideration is an evaluation of the extent to which a given plant is likely to obtain similar types of numerically controlled equipment. The issue is one of compatibility. Manufacturers are obviously not concerned that input instructions for a contour milling machine are not usable on a positioning table. But they are concerned that two pieces of equipment in their plant designed for and capable of handling a given workpiece might require two programs—differing both in media size and code form. Then there are little things even when the medium and general code form are in agreement. For example, alphabetical notations might represent different things, such as when axes of movement are designated x, y, and z in one case and a, b, and c in another.

The desirability of standardization is not an accepted conclusion in the industry. Control and equipment manufacturers recognize that numerical control is still in its infancy and that time will undoubtedly bring many improvements. They can



Four horizontal spindles on this special machine built by Barnes Drill Co. are selectively used to perform multiple operations on workpieces positioned by rotary table. A General Electric Co. tape system controls the unit.



These two Lahr Machine & Tool Corp. deep-hole target drilling machines can drill holes in tube sheets up to 24 inches thick. Tape control systems built by Control Instrument Div., Warner & Swasey Co. determine positioning and other cycle actions.

foresee, however, that standardizing too soon on a given technique will tend to stifle improvements. This type of problem exists in the data processing field to various degrees and it is worth noting that they have solved it in places by developing special equipment that automatically and rapidly converts data from one code to another and from one format to another. At least one manufacturer has anticipated the general problem and as a solution offers a replaceable plugboard in the control unit. This technique could be adapted to code conversion.

Importance of Transducers

A review of the circuit details of the variety of numerical controls that have been developed reveals that there is a great deal of art to the science of control design. Presumably starting out with the same general design aims, control designers have been able to combine components in a multitude of ways in achieving unique systems. Control designers are generally aware of end-users' concern, and the general lack of experience, with complicated electronic gear. Assuming the ability to function in the desired manner, the major goal in all designs is a relatively simple but reliable control system that can stand-up under continuous, industrial-type use.

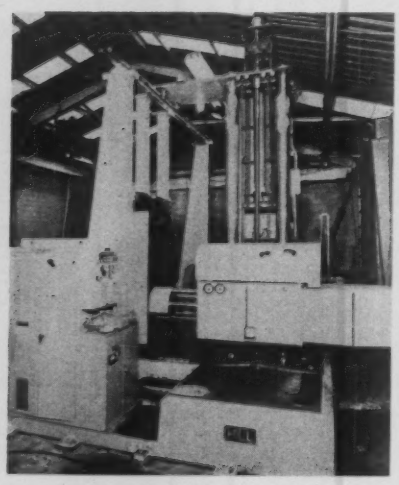
As a broad generalization, numerical control circuits are designed to accomplish the functions indicated in *Fig.* 4. This diagram represents the typical feedback diagram for a motion type control system but has been cast in a somewhat different form to highlight the information flow in such controls. Though the control of motion will be implied in the further discussions of control circuits, it should be appreciated that not all systems involve the elements that will be discussed. For example, programmed input commands for a testing operation might be used in a selecting mode to connect various circuits in some desired sequence for a desired time; what occurs following the establishment of the desired circuits would not necessarily be routed through a comparator to control an actuator. In other applications, the programmed instructions can call for an action to proceed until terminated by a limit-switch, again deviating from the generalized diagram in that a dynamic comparison of programmed and feedback signals is not required.

The diagram, then, is that of an error-controlled system. The general problem in such systems is to manipulate the command and feedback signals such that they can be compared, and to provide an error signal in the proper form required by the actuator. Different forms of signals within a system arise because of the different requirements in various parts of the system. Thus, the command instructions might be initially in a decimal digit form because it is desirable for the operator to be able to read the stored data on the medium. A feedback signal might be created in analog form because it is desired to use a certain transducer with certain performance characteristics. A comparator might manipulate signals in digital form in order to obtain the accuracy advantages in handling digital information, but the output of the comparator will require conversion to an analog form to operate an actuator.

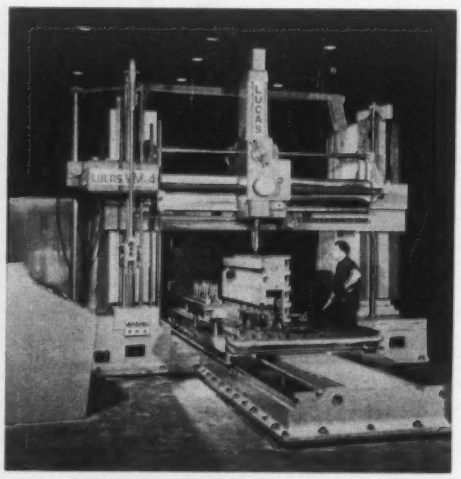
It is apparent that if the actuating signal results from a comparison of the programmed signal with the feedback signal, then the means of creating the feedback signal by a transducer is as important to the system as the original data preparation.

Several Are Required

More than one transducer can be required for each axis of motion to be controlled. This is a matter of practicability. A majority of systems are "absolute" in the sense that all measurements are related to a common datum point, as distinguished from "departure" in that a measurement is simply related to the previous measurement. For absolute systems, to obtain precision with transducers of a limited resolving capability, that capability must be devoted to identifying the smallest increments of position. This in turn creates the need for additional components which can clear up the ambiguity created by the



Gun drilling machine by Walter P. Hill Inc. drills tube sheets under tape control. Control system manufactured by General Electric Co. controls positioning and machine cycle.



Vertical spindle transverse position, feed depth, and longitudinal travel of table in this machine built by Lucas Machine Div., New Britain Machine Co., are controlled by General Electric Co. system. Automatic tool changing is also provided by positioning spindle over selected position in tool rack.

cycle of signals as the basic transducer senses lengthy movements. Often this results in a digital array of transducers that for illustrative purposes can be compared to the speedometer in an automobile.

The required multiple number of transducers can be obtained by coupling of similar type units through a gear train. For instance, as many as five digitizing discs might be geared together to obtain a signal that is to identify tens, units, tenths, hundredths, and thousandths of inches. The transducers, however, need not be of similar types. For instance, synchros might be used to obtain "coarse" positioning and a differential transformer to obtain "fine" positioning. In all of these types of systems, circuits provide for a smooth transition between the several stages of control.

Transducers that are used in the various systems can be classified broadly according to the type of signal, digital or analog, that is generated. Here a digital signal is to be thought of as a unit type (incremental) signal consisting of pulses that require counting to convey information, or as the output of a group of signal channels that convey information according to which signals are present (*on-off*) at any given time. The latter type represents information in coded form.

Commutating type transducers are used in a number of systems to generate digital signals, both in incremental and coded forms. A typical approach is to mechanically couple the transducer to a rotating member of the equipment being controlled. Usually this is the leadscrew, or when one is not present, a measuring leadscrew can be included as part of the control gear. As the leadscrew turns, it drives contact brushes across a surface consisting of an alternate arrangement of conducting and nonconducting material (an opposite arrangement as to what is driven is also possible). Constant making and breaking of the circuit creates pulses that can be counted to indicate turns of the leadscrew.

As a variation of this approach, a magnetic proximity device can be made to generate pulses by sensing the rotation of a toothed disc. As still another variation, a photoelectric system can be made to sense the rotation of a slotted disc, or movement of a linear scale containing a pattern of lines. An interesting form of this latter type uses a short and long section of diffraction grating. The short grating is slightly inclined relative to the long grating and is mounted in a stationary position. As the long grating, attached to the moving part of the equipment, passes beneath the stationary grating, a distinct interference pattern is created that appears to move across the surface of the short grating. The photoelectric system counts the interference patterns as they pass beneath the sensing head.

Steps Toward Use of Numerical Control

Five-step approach is suggested by General Electric Co. for consideration by the management of all manufacturing companies:

1. **Check present costs to pinpoint potential applications.**

   Thorough analysis will pinpoint high-cost factors and help you locate probable areas of greatest savings with numerically controlled machines.

2. **Accurately establish functional needs.**

   Specify true needs. Such specifications permit a machinery builder to determine the best means of meeting your needs.

3. **Call in your machinery and control suppliers.**

   The know-how available from these experts can be of real help. Through experience gained on other jobs, they can provide valuable guidance to your manufacturing engineering people.

4. **Evaluate over-all considerations.**

   With the specification made and the quotation received, evaluate the proposal on the basis of all significant considerations, translated into dollars.

5. **Plan full integration.**

   Plan and schedule full integration into your operations. Since benefits accrue to many plant functions, representatives from each operation should be called together to plan optimum use of numerically controlled machines.

Horizontal spindle jig borer and milling machine built with punched tape control by Giddings & Lewis Machine Tool Co. incorporates automatic positioning and cycle control.

Vertical hole grinder and its punched tape control system were built by Pratt & Whitney Co. Inc. The workpiece is positioned and the machine cycled by the control system.

To return to discs, coded digital signals can be generated by using a number of sensing heads, each reading a separate track, and arranging the conducting and nonconducting elements on the tracks in some pattern such that the angular position of the leadscrew at any given time is represented by a distinct pattern of signals. Thus, with four reading brushes in a transducer, 1/16 of a turn might be represented only by Brush 1 contacting a conducting element; and 3/16 of a turn might be represented only by Brush 1 and Brush 3 contacting conducting elements, etc. In that the coding discs deal with the presence or absence of a group of signals in a pattern, the pattern of conducting and nonconducting elements can be designed to indicate position in binary numbers or some variations such as binary coded decimal form.

Coding discs are useful analog-to-digital converters particularly in that a digital representation can be obtained directly. A shaft position can be indicated even though the shaft is not moving (a pulse counting system only generates pulses for a moving shaft, and counting devices must be provided to remember a location). A great deal of development effort has been, and is being, expended to make coded discs suitable for many types of industrial uses.

▶ Analog Types

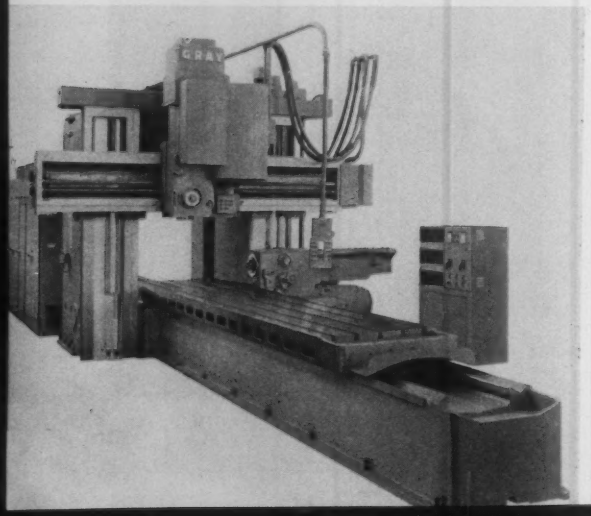
Transducers that generate an analog signal include those designed around synchros, resolvers, potentiometers, differential transformers, and precision measuring bars. A synchro is an inductive device that can be considered as a form of variable coupling transformer containing several (usually three at 120 degrees) stator windings and a single rotor winding. The rotor can be positioned through suitable mechanical coupling to equipment being controlled. With excitation of the stator windings by voltages varying in amplitude in a given manner, there will be a distinct rotor position at which the voltages induced in the rotor winding cancel. As applied in point-to-point positioning control, voltages representing some desired tenths of a shaft revolution are fed into the stator windings and the system is driven by the voltage induced in the rotor winding until the null point is reached. A resolver is a form of synchro containing only two stator windings located right angles to each other. It is applied in the same manner as a synchro.

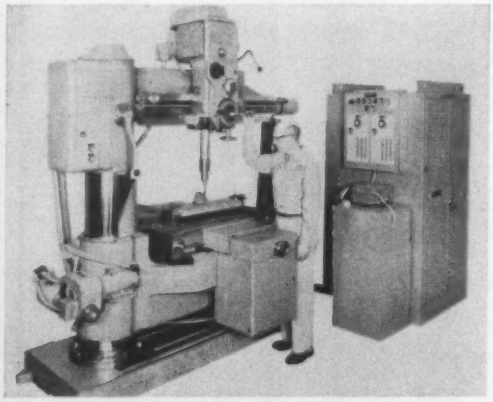
The basic principle underlying these types of inductive devices lends itself to variation, as does the method of construction of windings. Several control systems employ position identification devices in which electromagnetic coupling between windings is used—an electrical reference signal at high frequency being applied to one winding with a characteristic of the induced voltage in the other winding being a function of a shaft rotation representing the actual position. Multiple windings can be produced on flat surfaces by etched circuit techniques, allowing small precision transducers to be manufactured.

TABLE 1—Past Applications of Numerical Control

arc welding	contour gaging	gear shaping
assembly	contour grinding	grinding
batching	contour milling	gun drilling
bed mills	contour turning	hole grinding
bending	deep hole drilling	horizontol boring
blending	die sinking	horizontal drilling
boring	drilling	inspection
broadcasting	dynamic testing	jig borers
cable forming	eyeletting	lathes
cam milling	flame profiling	layout
cavity milling	frit spraying	map reproduction
circuit board drilling	gaging	milling
circuit testing	glass processing	missile testing
coil winding		multispindle boring
concrete batching		

Planer type milling machine produced by G. A. Gray Co. has control system built by Norden Div., United Aircraft Corp. The punched tape system controls automatic cycling and work positioning.





Radial layout machine manufactured by Fosdick Machine Tool Co. is shown with General Electric Co. positioning control. Punched tape is the control medium.

- photographic typesetting
- piercing
- planer mills
- positioning tables
- press feed lines
- profile mills
- punch presses
- punching machines
- radial drills
- riveters
- rolling mills
- rotary milling
- sandslingers
- shapers
- shears
- skin mills
- spar mills
- special machines
- spot welding
- spraying
- stretch-forming
- tables, rectilinear
- tables, rotary
- target drills
- telephone call routing
- template grinding
- testing
- transfer machines
- tube flaring machines
- turbine blade milling
- turret drills
- turret lathes
- turret punch presses
- typesetting
- ultrasonic inspection
- vertical milling
- vertical turret lathe
- weighing
- welding
- wiring machines

When the design of these types of devices results in a voltage output that varies linearly with the shaft position, they are generally referred to as inductive potentiometers. In producing a voltage analog of position, the typical resistance potentiometer can, of course, be applied, but special forms have also been developed. For instance, the potentiometer can be tapped to provide distinct contact points that divide the total resistance into decimal segments.

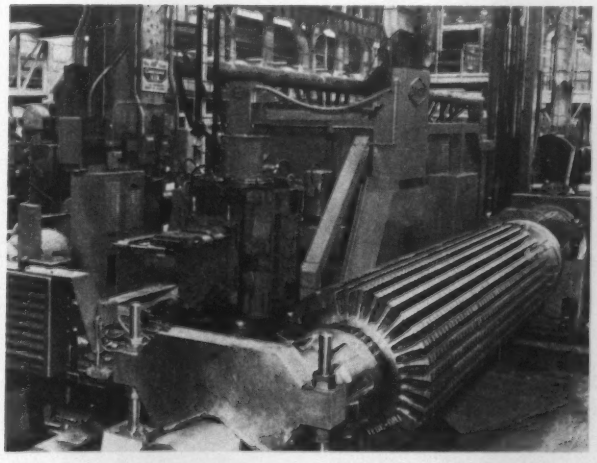
Differential transformers are also inductive devices in which a voltage is produced that is proportional to relative displacement of two electromagnetically coupled elements. The basic form is one in which the position of a magnetic element relative to primary and secondary windings is varied by a mechanical force, thereby changing a flux pattern and influencing the output in the secondary. Based upon this general principle, a number of accurate transducers have been designed to produce a voltage that varies with position, obtaining a succession of signals as a secondary coil is moved over a primary coil containing two windings precisely spaced apart.

Electromagnetic coupling can also be used to obtain a precise positioning feedback signal by indicating a null, as when an electromagnetic sensing head containing two balanced coils is exactly centered over a precisely located magnetic slug. Applying this approach, the slug can be displaced and the system driven by a fixed pickoff head until the null is reached, or the pickoff head can be displaced and the system driven to null relative to a fixed slug. Several precision measuring bar systems have been designed around the latter principle, the measuring bar containing a number of accurately spaced slugs along its length.

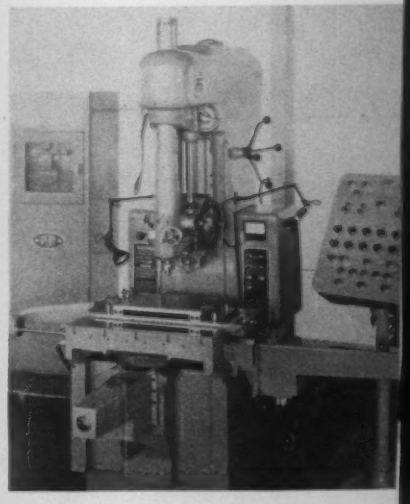
There are also measuring bar systems in which the feedback signal indicating that a position has been reached is obtained from a limit switch. These systems cause a number of separate length gages equal to the desired position to be arranged in a stack. With actuation of a drive, the equipment is moved against the stacked gages until the limit switch is actuated, signalling that the desired position has been reached.

Somewhat related to the measuring bar systems is one involving a series of precisely located pins, spaced in either a linear or circular arrangement, and a limit-switch mounted on a separate slide. The limit-switch can be positioned automatically at some position that represents a division of the distance separating two pins. The system provides for a pawl to drop in behind a given pin, and for the equipment to drive the pin against the pawl at creep speed, thereby moving the pawl assembly. The desired position is reached when the moving pawl assembly actuates the limit-switch.

From this brief review, it is apparent that a great variety of methods can be used to produce an electrical representation of motion and position. It should be appreciated that these forms by no means exhaust the list of available transducers. For example, tachometers can provide velocity signals; strain-gages can provide weight signals; and thermocouples can



Special machine with four-way turret performs drilling, reaming, tapping, and spot milling operations on generator rotors. Built by Baker Bros. Inc., the machine uses a tape system by General Electric Co. to control longitudinal carriage positioning and feed and indexing motions.



Jig borer built by Moore Special Tool Co. Inc. has positioning controlled by tape system from Sperry Gyroscope Co. of Canada Ltd. The punched tape is read pneumatically.

provide temperature signals, etc. However, the types mentioned are those typically found in numerically controlled positioning systems and are perhaps more complex in that a physical motion is being converted into a signal.

Signal Manipulation

Before the command signal and feedback signal in a system can be compared it is necessary that they be in the same form. And the error signal resulting from the comparison must be in a form acceptable to the actuator. These considerations introduce the problems of converting from one code to another, analog-to-digital conversion, and digital-to-analog conversion.

Code conversion is based upon data handling techniques and circuits involving networks of logic elements, storage devices, and switching components—both electromechanical and solid state forms. Perhaps the most prevalent code conversion problem that occurs with positioning systems is the need to convert from the binary-coded decimal form (8421 code, etc.) to a straight decimal form. Punched tape is a popular input medium, and binary-coded decimal information and alphabetical notations are readily punched into the tape by available equipment containing a typewriter keyboard. Within control systems, the use of digitizing devices and decimal divisions can be a convenience. In bringing the command and feedback signals into the same form it is a relatively simple matter to provide a switching network to convert the binary-coded decimal information into straight decimal information.

As regards analog-to-digital conversion, a number of the types of transducers which have been described are, of course, analog-to-digital converters, in that position is converted to a digital representation. But the problem of converting analog signals into digital signals also arises, though apparently not very frequently in positioning systems. Conversion can be based upon some technique in which, in connection with a master oscillator and gating circuits, some characteristic of the signal voltage is compared to a known voltage. An output of such circuits is collected in a counter, giving a digital representation of the analog signal.

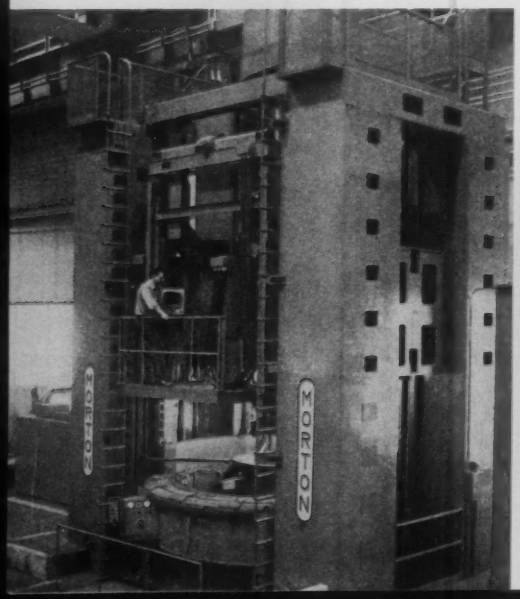
The need to convert a digital signal into a voltage analog occurs in a number of systems, an analog signal being required by the transducer and/or actuator. Conversion is readily accomplished by various types of switching circuits. For a given digital signal, certain switches are operated to establish a network, the output of which is a voltage proportional to the original signal. A network of resistors might be so established, or the switches can select appropriate taps on a transformer.

From the previous discussion of transducers, it is apparent that with some forms, the actual "comparison" of input and feedback signals is obtained within the devices. For example, the synchro is excited

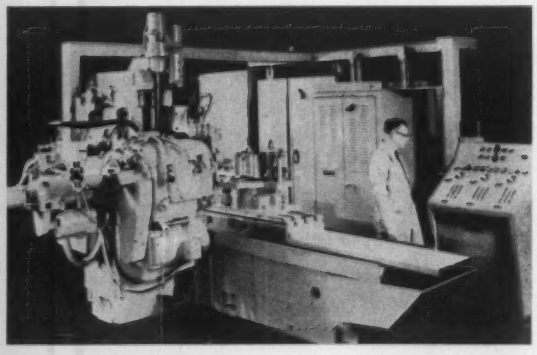
Numerical Control and Machine Tool Applications

As suggested by Ex-Cell-O Corp., areas where numerical controls can be applied are:

- Where the number of operations on machining set-ups are many.
- Where the operations of the machine are involved and multifarious.
- Where the run time of the machine, in relation to the machine set-up time, is disproportionate.
- Where it is essential to reduce lead time to the barest minimum.
- Where the part produced is complex and yet must be produced in comparatively short production runs or with individual variations.
- Where the part is so complex that producing large quantities can involve extraordinary possibilities of human error, whether machine error, dimensional error, or gaging or checking error.
- Where design or function or dimensions of a part can vary so widely that to maintain a sufficient inventory of finished parts would be economically impossible.



Vertical boring machine four stories tall uses tape control to set vertical and radial positions of tool. Machine built by Morton Mfg. Co. uses a General Electric Co. positioning system.



Horizontal drilling machine built by Sundstrand Machine Tool Div., Sundstrand Corp., has positioning control system manufactured by General Electric Co.

by a signal representing the desired amount of shaft rotation; the output is the error signal representing the extent to which the actual shaft position differs from the desired position. There are, however, a number of systems in which a comparison is made of two independent signals to obtain the error signal. Comparison can be obtained by various techniques, including Wheatstone-bridge circuits, pulse counters which can distinguish between add and subtract pulses; logic circuits that perform arithmetic manipulations; and phase-detection circuits. The problem of comparison can involve means to determine directional sense of the signals. Where coarse and fine measurements are involved, perhaps with separate actuators to be controlled, the circuits must provide a means of phasing in the several elements of the control signal so as to obtain a smooth uninterrupted movement of the member being positioned. And with but one or two exceptions, in which a pulse motor is being controlled, a digital error signal must be converted to a proportional voltage signal. As a general case, the signal is then amplified in order to actuate the equipment drive.

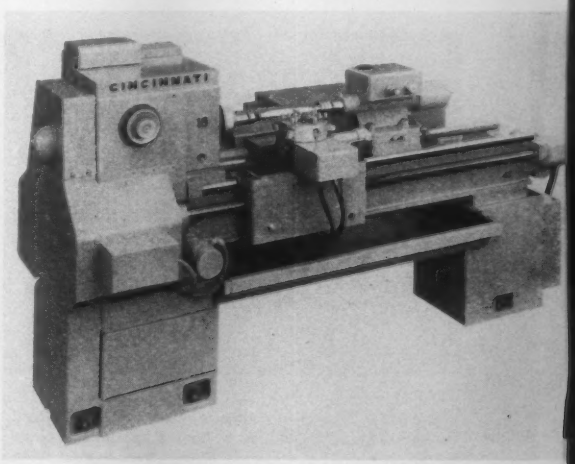
▶ Various Drives Are Used

Associating the term "servomotor" with small, special-purpose devices such as are found in aircraft control systems, some would-be users of numerical control equipment look askance when servomotors turn up in systems designed for industrial applications. It is reassuring to review the drives and power devices that have been used in numerical control systems. Such a list would include hydraulic units, for example electrohydraulic valves controlling cylinders and piston-type hydraulic motors. Electrical motors of various types, with a variety of clutching and braking devices, have been used to satisfy different requirements for coarse and fine movements. For example, one system has employed a constant speed unidirectional 1 hp ac motor in combination with direction clutches and control clutches that can be electrically selected for direction and speed range. Another system uses a 2 hp ac motor for rapid traverse and a 1 hp adjustable speed dc motor in combination with a clutch selected two speed gear train. A system has been designed that uses a single motor which, through clutches, is shared in positioning along two axes. Still another system employs three drives for one axis of motion, employing a hydraulic drive, an induction motor, and finally a dc shunt motor for creep speeds. In short, the types of drives suitable for positioning control include hydraulic motors, hydraulic cylinders, ac motors, and dc motors.

From the types of drives used, it is apparent that two forms of motion control are involved: One is a proportional type—in which all motion, including that during deceleration, is completely controlled. The other is an *On-Off* type—in which motion at some constant speed must be braked in stopping. Dc motors and hydraulic drives can be used to obtain proportional control. A dc motor is suited to general applications; however, its use is limited by the number of starts and stops per unit of time which might occur. Hydraulic drives are not limited in this respect, and under the control of proportional valves, hydraulic drive performance compares with dc motors.

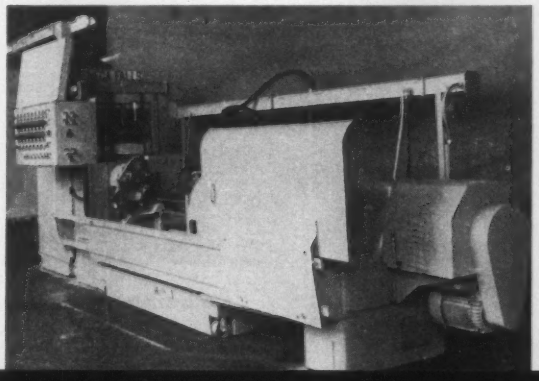
As to the second type of motion, acceptable performance is obtained with constant speed ac motors that are provided with clutches and brakes. Hydraulic motors and cylinders controlled by solenoid valves are also used. An important consideration in these systems is the stopping characteristic of the drive. Since it is not controlled, it must be consistent —a requirement leading to two-step systems in which motion is brought to a creep rate prior to being stopped. This approach fits in quite nicely with positioning measuring systems in which control information is available in coarse and fine categories.

Techniques and systems for numerical control, such as those described, are tools available to manufacturing engineers for use in operations where they are technically and economically feasible. But what types of functions and specific applications have been found feasible? What additional applications seem



Turret lathe manufactured by Cincinnati Lathe and Tool Co. was built for step turning work. The machine uses a Cincinnati Milling Machine Co. system to control point-to-point movement of the cutting tools, selection of desired one of six turret positions, and machine cycle.

This lathe and numerical control system were built by Seneca Falls Machine Co. Both carriage and 90-degree cross slide are automatically moved to programmed positions.



likely? What considerations have been found important in justifying applications?

The types of operations on which numerical control has been applied have been scattered across a wide spectrum, TABLE I. They have ranged from simple to complex operations—some in small shops and some in huge plants. Applications have included additions to existing equipment and systems integrally designed from scratch as part of newly conceived processing installations. Many of these applications have been the result of work by teams of trained engineers and skilled technicians; others are credited largely to single individuals.

TABLE 2—Basic Functions Under Numerical Control

1. Selecting
   - Which actions?
   - In what order?
2. Controlling Limits
   - Where does the action begin?
   - Where does the action end?
3. Continuously synchronizing
   - Co-ordinating variable rate actions?
   - Continuously varying a rate with time?

Basic Functions

In the array of applications that have been made, there are underlying similarities in types of basic functions performed under numerical control, TABLE 2. As shown, a simple classification system recognizes three general types of functions: 1. Selecting. 2. Controlling limits. 3. Continuously synchronizing.

The selecting function determines what action or actions are to be performed from among all those possible by a given equipment installation under command of the numerical control system. This is the choosing of what actions are to occur; a programming of which possible actions are to be used. One phase of the selecting function is the sequential arrangement of the actions to be used. The order in which events are to take place in time is determined by this sequencing phase. However, the point in time at which a given action begins, its duration, magnitude, rate, and the point at which it terminates are not controlled by the selecting function and its sequencing phase.

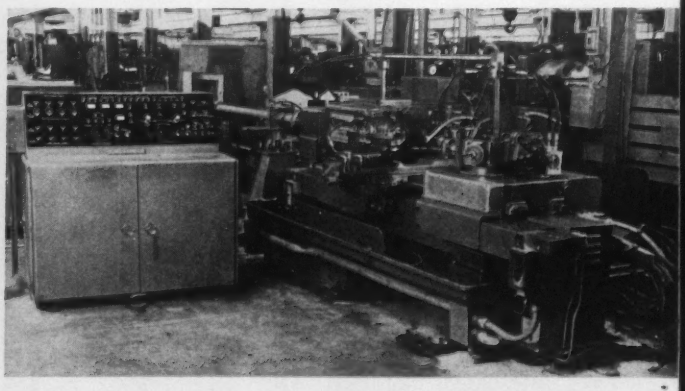
Requirements for the selecting function are based on the task to be done and the operations which the basic equipment can perform. For a drilling and tapping job on a turret type machine, the selecting function would indicate which spindles on the turret were to be used and would call for the drilling operation first. Where different electronic components are to be inserted into circuit boards by a single inserting head, the selecting function would call for delivery of the desired components to the head in the proper order.

In some cases there may be no particular sequence required by inter-relationships between the actions to be performed. The sequencing phase in such cases may only be a systematic method to incorporate all desired actions into a program. However, it may still be advantageous to determine a preferred sequence for the operations as a means to minimize cycle time. For instance, in drilling several holes in a workpiece, over-all cycle time may vary considerably depending on the order in which the holes are drilled. This is true even when all the operations are performed with the same drill; when tool changes are involved, proper sequencing becomes especially important.

Initation, duration, and/or termination of actions are determined by the function of controlling limits. Under numerical control this type of function determines the starting and stopping points of the actions by instructions in the program. This is in contrast to the use of limit switches, mechanical limits, or manually-set stops frequently used for other types of automatic control of this function. In a batch weigh-

Lathe has punched tape control of spindle speed, carriage position or feed, and cross slide position or feed. Unit was built by Monarch Machine Tool Co. and has a General Electric Co. control system.

Tape controlled turret lathe and its control system are manufactured by Jones & Lamson Machine Co.



ing operation, the controlling of limits can be a numerically controlled function that controls the point at which feed from a given material source is stopped. When a weight designated by the input command is reflected by the weighing mechanism, the control system is triggered to its next action. In the operation of a rotary positioning table, the function of controlling limits determines the point at which rotation of the table is stopped. If two fixed speeds of rotation are used, the limit controlling function will determine the points at which speed changes are made. The selecting function will control the sequential selection of speeds when the command points are reached.

The limit controlling function requires some means to establish the limit point which is to be attained. In numerical control systems this function also uses a means to feed back sensed information indicating the progress of the action toward the desired point, or at least to indicate when the point is reached. For example, where a ball nut is used to obtain linear motion from the rotation of a screw, the limit point may be established as a certain number of turns of that screw. A sensing arrangement can then count the number of turns made during the execution of the action. When the preset number of turns is indicated, the limit controlling function stops the screw and initiates whatever succeeding actions are desired.

A further function incorporated in many numerical control systems is the ability to continuously synchronize the performance of an action with respect to other occurrences. Though many operations are carried out at a single fixed rate or several fixed rates selected in sequence, many other operations require more versatile control of the rate of performance. For such applications the control system may include provision to vary the rate and synchronize the performance of an action with the passage of time or with the performance of other actions.

Such synchronization may be required to obtain the desired result from the actions performed. For instance, in an electronic circuit tester the reference level against which an output value is compared may have to be varied in a certain relationship to a varying input to the unit under test. In a two-axis profiling operation, it is necessary that the rate of motion between tool and workpiece along one axis be properly synchronized with the rate of motion along the second axis.

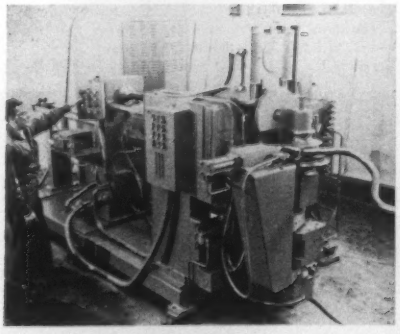
In some applications, numerical controls perform only one of these basic functions; in other applications they may perform all of them. The degree of complexity of the control system is not necessarily indicated by which of the basic functions it performs. Other factors also influence the over-all complexity of the system—number of possible actions, speed of performance, range over which an action is to extend, degree of precision. These and other factors may overshadow the complexity requirements for functions which are normally more sophisticated.

Generally, however, it may be expected that systems including the continuous synchronizing function will be more complicated than those which perform only the other two functions. One reason this is true is because controlling of limits and selecting of actions are usually numerically controlled when continuous synchronizing is so controlled. Similarly, selecting is usually included under numerical controls for controlling limits. In addition, continuous synchronizing normally requires greater system refinement than does limit control, which in turn is generally more sophisticated than a selecting system.

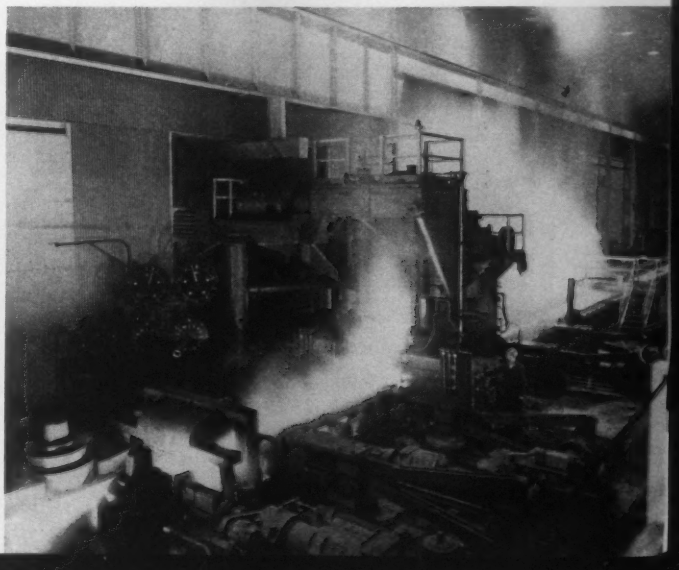
▶ Selecting by NC

The need for choosing desired actions from the actions possible and fixing their sequence is universally found across all types of industries. Since this requirement is so widespread and the control system required can be relatively simple, performance of the selection function has been accomplished by numerical controls in a great many cases.

Historically, a selection function was the first to be performed under punched card control. In 1801



Machine to bend automotive tailpipes to order uses punched tape to control advance of pipe into bending station, rotation of pipe, and degree of bend. This unit was built by Baldwin-Lima-Hamilton Corp. with controls by General Electric Co.



Reversing roughing mill to roll steel slabs was built by Mesta Machine Co. Punched card control system supplied by Westinghouse Electric Corp. adjusts mill openings, edger roll openings, and speeds besides programming other functions.

the Frenchman Joseph Marie Jacquard was awarded a bronze medal for his development in control of weaving machines. Holes in a train of card elements were used to reproduce a desired weaving pattern on the Jacquard loom. It is reported that there were some 11,000 such looms in France by 1812.

In modern day applications, other media such as punched tape and magnetic tape, as well as punched cards, are being used for numerically controlled selection operations. Generally, if only a selection operation is to be controlled, punched tape or punched cards are used.

Since the operation performed manually by an operator at a keyboard or pushbutton station is the basic selection function, numerical control of selection is widely found in this area. Perhaps the most universally used equipment of this type is the tape controlled typewriter. Closely akin to this application is the use of punched tape to automatically control the casting of type to be used in printing. Both of these uses of numerical control represent simply a refinement of control applied to equipment whose basic operating principles remained the same as they were under manual control. As such they are representative of a great many potential applications in other operations.

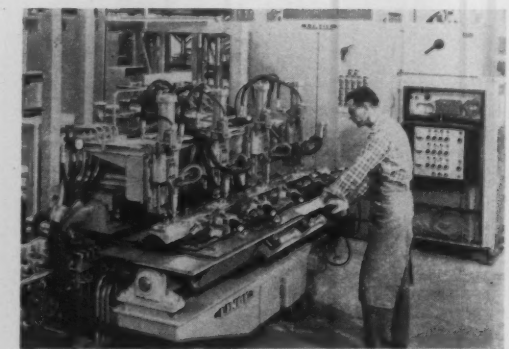
Numerical control of selection is also built into new types of equipment in the printing industry. As an alternative to the type casting process, images of desired type characters can be photographically arranged on film. Printing plates can be made directly by photoengraving from the film. Individual characters are selected in desired sequence and photographically transferred to the film from permanent masters. In one system the master is a vinyl disc bearing nearly 500 images. In another system, the type characters are recorded on 18 masters on a turret device, each master having 88 character images. Control of the selection process in both of these systems is by punched tape.

Other operations where numerical control has found important usage for control of sequential selections lie in the areas requiring repetitive execution of long chains of selection actions. Typical of these operations are inspection and testing applications. Punched tape has been used to control the indexing of a scanning head to successive fixed positions and also program the other actions in an automatic ultrasonic inspection installation. Echo signals are plotted on a chart as the test is automatically performed. Defects within the part are quickly observed. This is a production line task which would have been tedious and impractical to perform manually.

Similar considerations have led to the development of many pieces of equipment for the automatic inspection and testing of electrical and electronic circuits and components. One example used in the telephone industry is a tape controlled unit to test relay panel assemblies before shipment to telephone central offices. The assemblies may have up to 97 terminals which are connected in desired patterns to 40 test circuits. The tape is inserted into the test set, quick coupling contact fixtures are attached to the assembly to be tested, a button is pressed, and the test is under way. If an expected response is not obtained on a given test, an associated trouble light flashes rapidly; if an unexpected response is received the light flashes slowly.

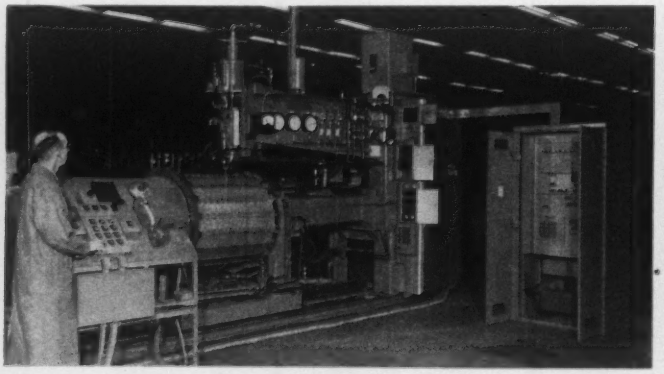
Selection and sequential performance of test cycles on individual electrical components under numerical control has been applied to transformers, relays, resistors, transistors, diodes, capacitors, and similar items. One unit to test ganged precision potentiometers is programmed by punched cards. About 50 measurements are required at pre-set intervals on each of 5 to 14 individual potentiometers in the ganged assembly. The shaft of the assembly is successively indexed through 360 degrees in increments of 7.5 degrees. The tester includes voltage selection and measurement of results. Up to 84 cards are needed to test a 14-potentiometer assembly. Deviation from specification requirements is indicated by a pattern of lights. The card controlled checker has resulted in a labor saving in this application of over 90 per cent.

A great many machine tools apply numerical control to selection functions. In most such applications the numerical control system also performs additional



Four-head shielded electric arc spot welding machine developed by Linde Co., Div., Union Carbide Corp., welds missile parts accessible from only one side. Machine, with mechanical and hydraulic elements by Expert Welding Machine Co., Div., Expert Tool & Die Co., uses a punched tape system by Farrand Controls Corp. to control cycling and positioning.

Tape controlled welding machine moves cylindrical workpiece to selected rotary and longitudinal positions and automatically cycles. Built by National Electric Welding Machines Co., the machine uses a General Electric Co. control system.



Management Problems with Numerical Control

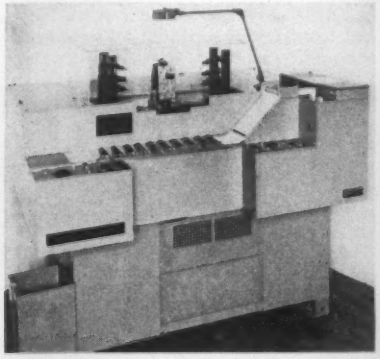
As with any other new idea or manufacturing method, numerical control poses some management problems. Giddings & Lewis Machine Tool Co. submits this list of items which can critically affect the success of an installation:

1. How to evaluate and select from the many systems on the market.
2. How to determine where to start or where to stop with numerical control for any one plant or company.
3. How to detail an economic analysis of proposed or existing numerical control systems versus conventional operation.
4. Who will be in charge of the numerical control projects and what will be his position in the company organization.
5. Higher initial investment costs per unit or per installation both for machine tool and control system.
6. How to achieve all the advantages potentially available through the use of numerically controlled machine tools.
7. A computer or computer time may be needed to achieve the optimum utilization of numerically controlled contouring equipment.
8. Assimilation of numerical control and its effects on
   a. Plant organization and management
   b. Personnel and training
   c. Quality control and inspection
9. How to effect a reorganization of maintenance procedures and personnel.
10. How to establish the new co-ordination required between engineering and drafting, production planning, tooling, and programming in addition to inspection and shop personnel.
11. How to prepare for delays, trouble, and nonfamiliarity with new equipment during shakedown stages.
12. Danger that rapid progress in the evolution of new systems and techniques may render some equipment obsolete.
13. Existing systems compatibility and work interchangeability.

basic functions in controlling limits of actions or continously synchronizing rates of performance. Typical selecting operations controlled include picking of motions to be made and choosing of feed rates and spindle speeds from several fixed values that are available. Auxiliary actions such as coolant flow and chip disposal are also programmed.

One of the auxiliary selection actions that has been numerically controlled in some interesting applications is the selection of tools. Well known examples of this type of selection are represented by turret drilling machines and turret lathes on which tools are individually mounted on different spindles or faces of a turret. To perform a desired operation the turret is indexed to bring the selected tool into working position. One tape controlled machine has a large circular turret carrying twenty spindles. On command, the turret indexes the desired spindle into position.

Other applications have provided means to change tools on a single spindle. One card controlled tool changing arrangement stores as many as 30 tool holders around the periphery of a circular index table. An automatic jaw mechanism transfers the tools back and forth between the vertical spindle of the machine and the assigned positions on the indexing storage table. Another design, tape controlled, provides storage for 30 tools in a drum-type magazine. In that system each tool holder is identified by code rings and can be stored and retrieved from random positions in the magazine. A rotating transfer arm places selected tools in the horizontal



Inspection machine with tape control system was built by Warner & Swasey Research Corp. As specified in the program, probes are automatically positioned to simultaneously check as many as 50 points on turbine blades.

Batching system for ready mix concrete ingredients selects materials from assigned bins and weighs out specified quantities under control of punched plastic cards. System was developed by Fairbanks, Morse & Co. with Butler Bin Co.

spindle of the machine and returns them to the magazine.

Tool selecting has also been card and tape controlled on turret punch presses. On a 100-ton press, 36 punch and die sets have been mounted on turrets 55 inches in diameter. The press can make about 30 hits per minute when approximately 3 turret shifts averaging 30 degrees each are made per minute, even when the workpiece is shifted between hits.

Because assembly operations involve many sequential selections, they too have been ripe for numerical control. For instance, one design of machine to insert components into circuit boards uses a single head to insert a variety of components. A circuit board is indexed under the head to successive locations determined by pre-set stops. The component to be placed is selected from one of 24 magazines by punched cards. A circuit board of average size, containing about 30 components, can be assembled in about 1.5 minutes on the machine. About 20 minutes are required for hand assembly of the same board.

A large riveter used to assemble aircraft panels uses holes punched in 35 mm film to control sequential steps in the machine cycle. Operations sequenced include positioning of the workpiece, drilling of rivet hole, insertion of rivet slug, upsetting of the rivet, and shaving of the head flush with the panel surface.

In another industry, a machine to make connections between electrical terminals can be controlled by punched cards. This machine makes solderless connections on both ends of a wire simultaneously on terminals selected by the program. Movable carriages can position two wire wrapping tools at modular points in the wrapping area. Use of the programmed machine consistently produces reliable connections.

Even in service type industries whose operations directly affect the public, card and tape controls have been applied to some of their operations for selecting and sequencing. In London, England, special punched tapes are used for signalling and switching actions controlling the movements of hundreds of trains daily. Magnetic tape is now used in some American broadcasting stations to select which recorded announcements and other program elements are to be played on night or weekend shows when studio personnel are gone. Automatic routing of long distance telephone calls is performed by equipment using special punched card type elements.

▶ Controlling Limits by NC

In terms of number of operations where a basic function is performed under numerical control, controlling of limits ranks second only to selecting of actions. Most of these applications are found in conjunction with provisions for numerical control of the selecting function. The single type of action covering the greatest variety of these applications is the controlling of limits of mechanical motions.

Determination of limits of mechanical motions under numerical control may be found especially in those operations where speed, accuracy, repeatability, and similar factors are important in the performance of the motion. Prime area of such operations is in the positioning of machine tool elements. Some of the additional applications are found on rolling mills, assembly machines, and gaging machines.

Universal machine tool building blocks, on which the limits of mechanical motions are numerically controlled, are workpiece positioning tables. Both rectilinear positioning units and rotary indexing units are available. These basic units have been used to improve performance of operations such as drilling, boring, reaming, tapping, and spotfacing on existing machines as well as on new machines. They may be interlocked with the machining head so that operations are performed automatically when positions are reached, or an operator may wait for the position to be reached then pull a lever, turn a wheel, or push a button.

Commercially available units offer a wide selection of capabilities with regard to size of workpiece that can be handled, area over which positions can be attained, speed of moving from one point to an-

Punched cards program this tester built by California Technical Industries, Div., Textron Inc., to inspect transformers, relays, resistors, transistors, diodes, capacitors, and similar items. Tests to be performed, values, and tolerances are specified on the cards.

Multiple-head drilling machine drills holes in stacks of printed circuit boards with positioning and cycling controlled by punched tape. Special machine and control system were built by Jones & Lamson Machine Co.

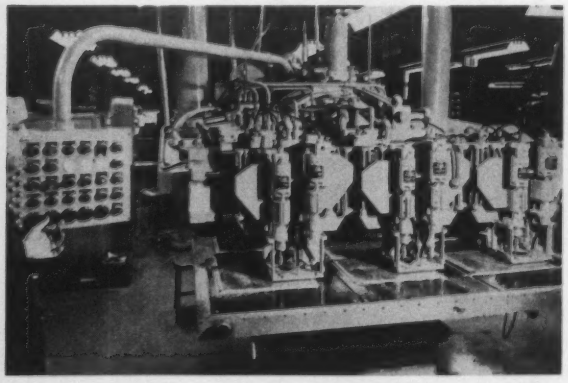
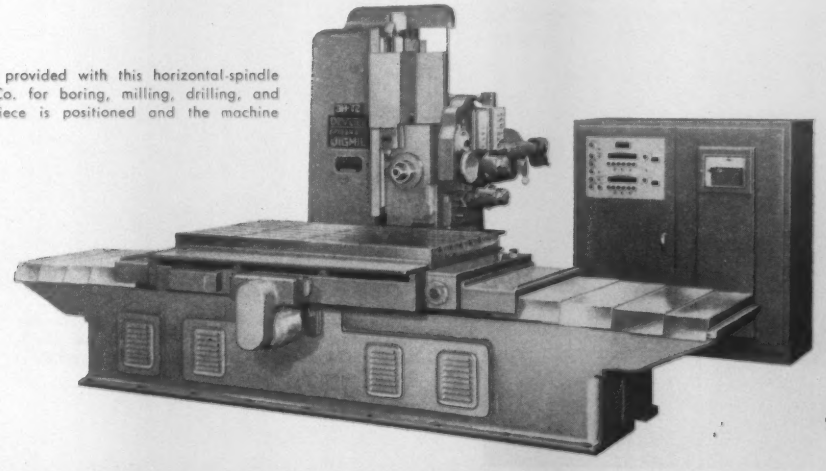


TABLE 3—Some Reports On Results With Numerical Control

Application	Former Method		Numerical Control	
positioning to drill 37 holes in machine tool table, center held ±0.001 inch	machining (horizontal boring mill)	5.5 hr	machining (numerically controlled positioning table)	3.8 hr
inspect cam profile	gaging (5 points ± 0.001 tolerance) (conventional)	1½ hr	gaging setup and program (33 points ±0.001 tolerance) (numerically controlled probe unit)	5 min 40 min
center drill and drill 100 holes, tap 68 holes, in rocket instrumentation panel, centers held ± 0.001 inch	machining (single-spindle drills and drill jig)	8 hr	machining (numerically controlled turret drill & positioning table)	1 hr
contour mill sculptured aircraft skin part	tooling first part ninth part (template controlled mill)	$18,467 1400 hr 950 hr	tooling first part fourth part (numerically controlled skin mill)	$1957 700 hr 300 hr
milling oil grooves and slot in 50-inch rotary table base	preparation (template controlled vertical miller)	54.3 hr	preparation (numerically controlled contour mill)	11.3 hr
turning oil well part	machining (vertical boring mill)	14 hr	machining (numerically controlled vertical boring mill)	1¼ hr
profile mill templates for tracer machines (average for 600 pieces)	labor cost machine cost material cost (tracer controlled mill)	11.9 hr. $72.40 $42.40 $ 5.95	labor cost machine cost Material cost (numerically controlled mill)	4.65 hr $29.60 $28.50 $4.48
bore and turn steel hub	preparation machining (tracer controlled vertical turret lathe)	22.5 hr 1.0 hr	preparation machining (numerically controlled vertical turret lathe)	4.4 hr 1.0 hr
contour mill aluminum fuel tank skin	preparation machining scrap (contour mill)	145 hr $1,198.08 3.25 hr $42.97 8%	preparation machining scrap (numerically controlled contour mill)	78 hr $758.54 1.42 hr $14.71 1%
produce honeycomb die cavity	preparation cast metal dies finish grind lead time (conventional)	400 hr 110 hr 60 hr 7 weeks	preparation machine die finish grind lead time (numerically controlled profile mill)	68 hr 24 hr 30 hr 3 days



Punched tape control system is provided with this horizontal-spindle machine by DeVlieg Machine Co. for boring, milling, drilling, and similar operations. The workpiece is positioned and the machine cycled automatically.

Potential Advantages of Numerical Control

Allow greater flexibility in product design.
Shorten lead time.
Eliminate complicated jigs and fixtures.
Eliminate need for templates, patterns, and models normally required in profiling and contouring.
Save storage space required for jigs, fixtures, templates, patterns, and models.
Eliminate layout.
Reduce time devoted by supervisors and operators to reading instructions and/or blueprints.
Reduce setup time.
Reduce operator decision time.
Reduce machining time.
Increase machine utilization.
Improve productivity.
Minimize changeover time.
Eliminate errors of omission and commission.
Increase accuracy.
Allow closer tolerances.
Increase product uniformity.
Reduce scrap and rework.
Allow planning and controlling of each cut at optimum conditions.
Increase tool life.
Consistent repeatability.
Rigidly maintains standard cycle times.
Improve scheduling and pricing.
Make right and left hand parts by simple reversal of control.
Less hand finishing.
Reduce handling of product.
Permit reduced product inventories.
Machines easier to operate.
Reduce skilled manpower requirements.
Less production space required.
Alternate sources of production can be quickly used by reproducing numerical control data.
Skills, know-how, and complete machine instructions are stored for ready use at a later date.

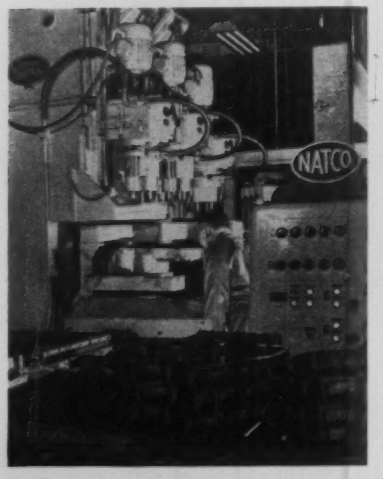
other, absolute accuracy, with which a specified point can be reached, and the accuracy with which positioning to a given point can be repeated. Punched tape, punched cards, and magnetic tape are used as control media for these units. Essentially, the rectilinear tables include a more versatile positioning action since they control motions with respect to two axes rather than the single axis of a rotary table.

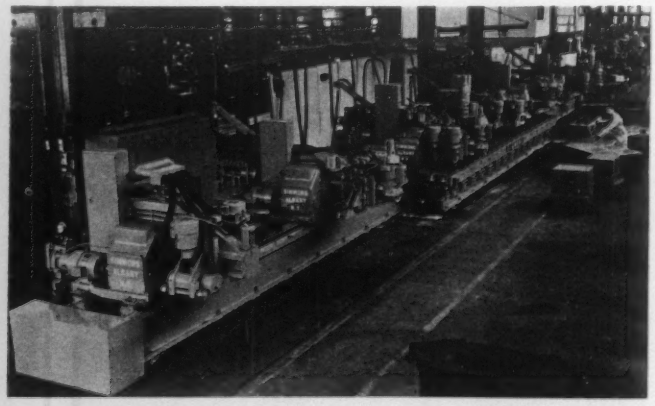
Mechanical cousins of these positioning table units are the tables, slides, saddles, and similar components built into machine tools and other types of equipment. Wherever such an element must be moved a controlled distance linearly or angularly, the use of numerical control is a distinct possibility. For most types of machine tools the possibilities have been seriously considered and many of the applications made.

A few examples will serve to illustrate some of this trend. Simple conversions of existing turret drills have supplied a numerically controlled positioning table and left turret shifting and control of spindle advance to the operator. A particular application of this type in one user's plant has been reported as generally giving savings in machining time of 30 to 40 per cent as compared to operations on sensitive drill presses using jigs or drilling to a layout on the workpiece.

A great number of newer turret drills include numerical control of turret position and spindle advance as well as workpiece positioning. One specific installation uses punched tape to control turret indexing, table motions in and out and left and right, spindle feed at one of six speeds, and spindle up and down motions. Operations on this machine are accurate to about plus or minus 0.002 inch. Savings have ranged from 30 to 70 per cent. In one case 100 holes were being drilled in a

Three-station machine positions workpiece under three heads in sequence of boring, chamfering, drilling, and tapping operations. Machine and punched tape control were manufactured by National Automatic Tool Co. Inc.





Special machine controlled by two card readers has six stations traveling on 80-foot ways past a 30-foot table for the workpiece. Built by Simmons Machine Tool Corp., the machine uses a General Electric Co. system to control 16 positioning motions and 33 other functions.

plastic part. Previous practice required 8 hours to lay out and machine the part. Under numerical control the total time required was 56 minutes, including 45 minutes for tape preparation and setup.

In a special machine for performing operations on the periphery of cylindrical parts, tape control of a rotary table is combined with control of four horizontal spindles. Control of spindle vertical position, spindle selection, and cutting depth are included. On this machine, positioning is within 0.003 inch, depth of cut within 0.001 inch, and repeatability within 0.0002 inch. For a jet engine compressor casing 248 holes are machined. Operations include rough drilling, rough facing, finish boring, and generating front and back parallel faces of all holes. The design includes three different hole sizes and requires up to four operations per hole, with the drilling job being completed in 4½ hours. A major advantage of the numerically controlled machine on this job is its dependable repeatability in performing successive operations.

Special machines for drilling deep holes in large workpieces such as tubesheets for heat exchangers and feedwater heaters have also been built with numerical controls. One manufacturer of such workpieces uses tape controlled machines to produce holes 3/16 to 1¼ inches in diameter in tubesheets as much as 24 inches thick. Previously these holes were produced by manually positioning a radial drill over a sheet on which the hole locations had been laid out. The tape controlled method results in labor costs about half those for the former method on a representative tubesheet 10 inches thick.

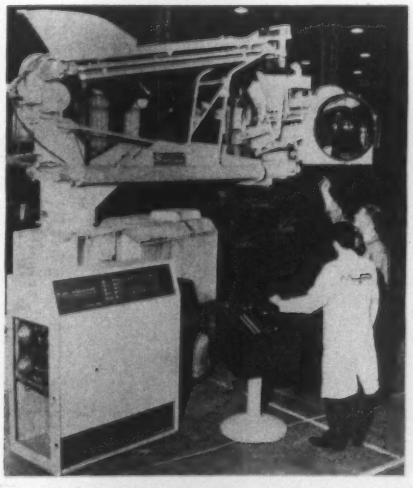
Similar control requirements have been met in the case of lathes for step turning operations. Sometimes known as straight-cut control, such systems control movement of the cutting tool along one axis of the lathe at a time while the work rotates. The distance which the tool advances is determined by a limit controlling system, but the rate at which it advances is not continuously synchronized with any other action under numerical control. Turning of contour shapes is therefore not possible on this equipment except as very rough approximation by a large number of straight cuts.

One early application to a step-turning lathe used punched cards to control positioning and feeding of the tool along an axis of the machine and selecting of spindle speed and auxiliary functions. Production accuracy on that particular unit has run plus or minus 0.002 inch on length and plus or minus 0.001 inch on diameter. Typical production experience on lots of a few pieces each has shown average savings of 50 per cent compared to conventional turning operations.

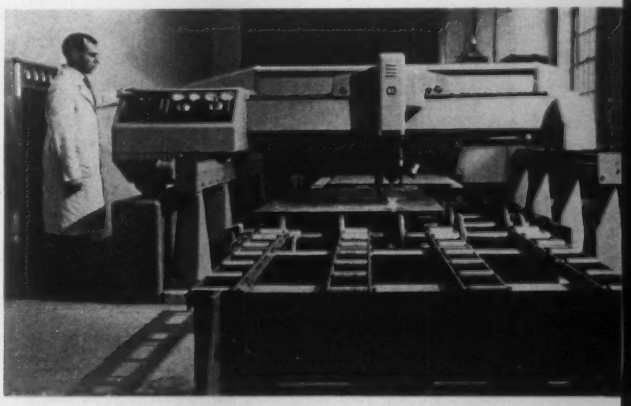
Even the area of the transfer machine has been entered by numerical control. One unit with three machining stations has been built with tape control. In fact, it has four tape controls, four tape readers being used to allow intermixed machining of four different part designs. As a given type part is advanced to successive stations, the reader loaded with the tape for that part is switched to control the machining operations at those stations.

The advantages of numerical control for controlling limits of mechanical motions have not been restricted to chip cutting machines. One design of tape controlled machine has been developed to produce the compound bends required in automobile tailpipes. A 16-foot length of straight pipe is fed through a chuck on the machine. The tape control determines the length of pipe fed through a bending station, the angular position of the chuck, and the degree of bending. One of the major reasons for this particular development is important in many other applications too—provision of sufficient production flexibility to allow important reductions in inventories without adverse effect on availability of desired items. In the tailpipe market there may be 700 to 750 different types in demand at a given time. With the numerically controlled tailpipe bender just four basic diameters of straight pipe can be stocked and bent to order to meet demands.

The rolling mills to produce steel and aluminum products have also felt the impact of numerical



Sandslinger to automatically ram medium and large molds in foundries was built by Beardsley & Piper Div., Pettibone Mulliken Corp. The record-playback type magnetic tape control system was supplied by Micro-Path Inc.



Large steel plates for shipbuilding and other steel fabricating industries are cut to shape by this flame profiling machine under magnetic tape control. Unit was developed by British Oxygen Gases Ltd. and Ferranti Ltd.

control. A 44-inch reversing roughing mill that is part of a hot strip steel rolling mill is one example. A card control system regulates mill screw-down opening, edger opening, mill speed, edger speed, and other variables on this heavy equipment. Under the card-programmed system the mill operator can press a single button to initiate the complete rolling sequence for a slab. With the large number of actions to be controlled and the importance of keeping the large mill investment at maximum productivity, numerical control is advantageous here just as in other situations with similar considerations.

Assembly operations requiring flexibility of locating actions are frequently fertile fields for numerical control of the limits of the actions involved. A tape-controlled shielded arc spot welder is used to produce such missile parts as control and dorsal fins. This machine has four welding heads and can weld four identical parts at a time. The welding torches are positioned along three axes by the control system, with relative positioning between welding torches and workpiece within 0.001-inch cumulative error in any of the three planes.

A machine to assemble wires into cable harnesses for switching equipment and related electronic applications is controlled by punched tape. The machine selects any of 60 color-coded wires, determines the origin and terminal points, and lays the wires along prescribed paths to form the harness.

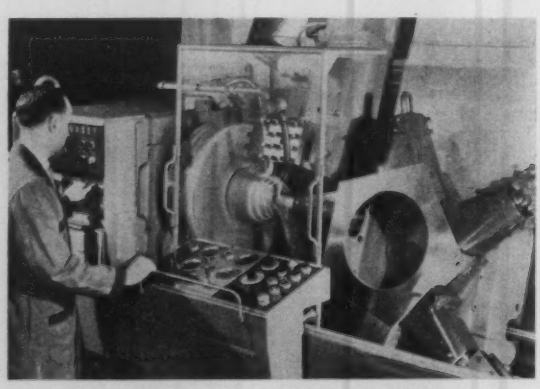
To assemble tabs onto the exterior surface of cylindrical tailpipe liners for jet engines, another punched-tape controlled welder is used. This electric spot welder positions the liner under the welding head with a linear and a rotary motion, each within plus or minus 1/64 inch. The control also regulates welding current and welding time. A part design calling for 1600 separate welds takes about 1 hour and 20 minutes with just one operator. Conventional methods require about 8 hours with two operators.

An automatic arc welder designed for general use on aircraft engine components is controlled by punched tape to make both circular and longitudinal welds. The tape controls four positioning motions: 1. Rotation of the workpiece positioning table. 2. Tilting of that table. 3. Horizontal travel of the welding head on a boom. 4. Vertical positioning of the rotatable boom on which the welding head travels.

Since numerical control offers advantages in the manufacturing processes that produce the workpieces, it is logical to expect some of those same advantages to be sought in the gaging operations to check them. One such application is a tape-controlled machine to simultaneously measure up to 50 dimensions on contoured surfaces of turbine blades. Slides carrying sensitive probe switches are positioned by the control system until they contact the part. If parts are within tolerances a green light flashes; if outside tolerances, a red light flashes and all deviations of actual dimensions from nominal are plotted on a graph.

Even equipment to accurately plot points on drawings against two co-ordinate axes is commercially available with numerical controls. Punched card or tape input to one design can position the plotting head over an area 47¼ by 47¼ inches. Maximum positioning speed is 3 inches per second and accuracy is within 0.0015 inch. In an interesting reversal of this role, such equipment has also been used to generate punched tapes for control of a positioning table on a production machine.

Mechanical motions form only one of the application areas for numerical control of action limits. Other actions which are represented by limits on voltages, currents, or numbers of pulses are being performed under numerical control. Batch weighing operations to meter out desired quantities of one or more ingredients are representative of this trend. In plants for loading ready-mix concrete trucks, numerical controls have been applied to control equipment feeding aggregates, cement, and water. One installation uses punched plastic cards to automatically weigh out batches containing as many as two out of three available cements, up to four of six stored aggregates, required water, and special additives. Up to 6 cubic yards of concrete



Numerically controlled turret lathe combines instructions from built-in memory with punched tape input to perform contouring operations. Tape input is used exclusively to generate contours in this system built by Warner & Swasey Co.

Magnetic tape control system is entirely machine mounted on turret lathe. Both machine and control were built by Gisholt Machine Co., and the system can perform simultaneous contouring operations with tool post and turret.

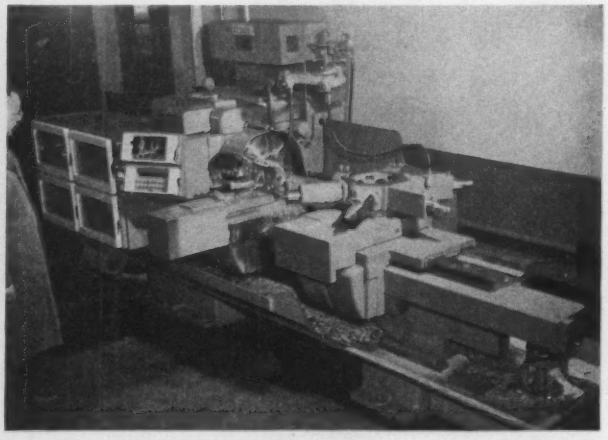


TABLE 4—Future Types of Applications of Numerical Control

(As foreseen by individual control builders for their equipment)

- advertising displays
- animation stands
- assembly
- beam punches
- boring mills
- brake presses
- drawing machines
- drill presses
- drilling machines
- dynamite machining
- gaging
- graphic arts equipment
- grinders
- induction heating
- lathes
- lofting machines
- measuring
- metal measuring and cutting
- mills
- missile gaging
- paper cutting
- planer type mills
- plotting machines
- positioning
- punch presses
- remote positioning
- repetitive testing of mechanical components
- riveting
- saws
- screw machines
- sequential testing
- shears
- skin mills
- slicing crystals
- special effects printers
- speed control
- spot welders
- spraying missile cones
- spring and cushion assembly
- transfer machines
- tube forming
- turret lathes
- variable processing
- vertical turret lathes
- welding
- wiring machines

can be batched and pre-mixed every 2 minutes. As in other batching tasks, consistent speed and accuracy of the numerical control system in weighing out ingredients are major factors in determining product quality and profit level in the operation.

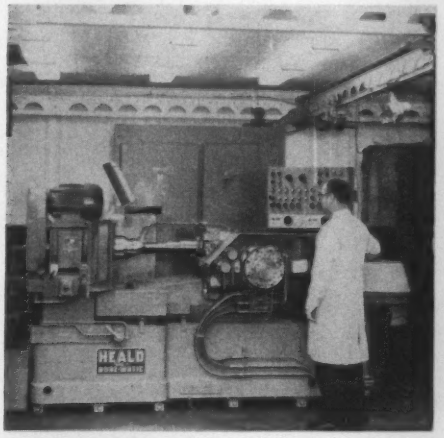
In a plant manufacturing organic bonded grinding wheels, equipment has been installed to weigh out materials for each batch of wheels under punched card control. Weighing carriers in this system travel on a monorail beneath bins containing the raw materials. Carrying a punched card calling for the desired ingredients for a batch, each carrier stops under the proper bins and draws off the specified weights of materials. The batches are then discharged to mixing equipment.

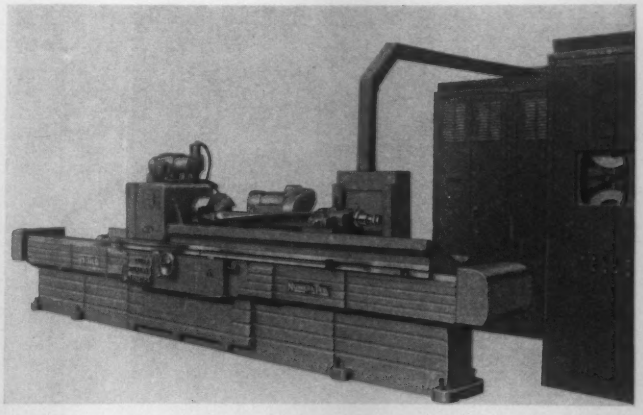
Testing in the case of many electrical and electronic components is improved by flexible provisions to automatically establish various input voltage and current levels. One commercially available automatic component tester uses punched cards to select tests and determine values and tolerances. A large variety of components can be subjected to complete series of tests. Shifting from testing of one type of component to testing of another type is readily accomplished by changing cards.

Control of the number of repetitive cycle elements is important in another application. A coil winding machine for stators of motors and generators is numerically controlled to insert the desired number of turns in specified slots. Indexing to wind successive coils is also controlled. Though many coil winding machines are equipped with counters to indicate when a desired number of turns have been inserted, the setting of these limits under numerical control adds further speed and flexibility to the winding operation.

Interesting combinations of operations have been made under numerical control of sequencing and limit controlling. In manufacturing certain high resolution printed circuit boards, between 200 and 400 holes must be precisely drilled in each board. They must be accurately positioned for proper elec-

Contour turning machine built by Heald Machine Co. can generate contours with tolerances of plus or minus 0.0001 inch. Table stroke and cross slide travel are numerically controlled by Cincinnati Milling Machine Co. system.





Complex shape of steam turbine buckets is contour milled as workpiece turns between headstock and tailstock of this machine by Ex-Cell-O Corp. Magnetic tape control system was manufactured by General Electric Co.

trical functioning and to avoid stoppage of automatic assembly lines. Tape control is used to direct positioning and drilling motions of several heads simultaneously over stacks of boards.

A 3-station machine to drill, bore, chamfer, and tap holes in flywheel housings is used in diesel engine production. Punched tape controls spindle motions and sequential positioning of the part at each station. Over 160 types of housings are processed in lots ranging from 10 to 500 parts. Machine cycle time is about 3½ minutes.

Another combined-operations machine is a complex giant used in production of hollow conductors for large electric power generators. To provide passages for coolant to carry heat away from the generator, copper extrusions receive about 250 operations such as wire brushing, slug insertion, slug welding, and milling at selected points. The machine ways are 90 feet long, 8 feet wide, and support a 32-foot table. Under card control each of six separate working heads in succession is brought into action.

Continuously Synchronizing

Generally most sophisticated of all are the numerical control systems that provide means to continuously synchronize performance of one action with the performance of one or more other actions. Historically there have been simple mechanical systems that provided fixed synchronizing functions—lead screws, cams, gear trains; but changing of synchronizing relationships meant changing gears or linkages, usually by manual manipulation. Smooth continuous adjustment of relative rates of travel along even two axes was not feasible by those means.

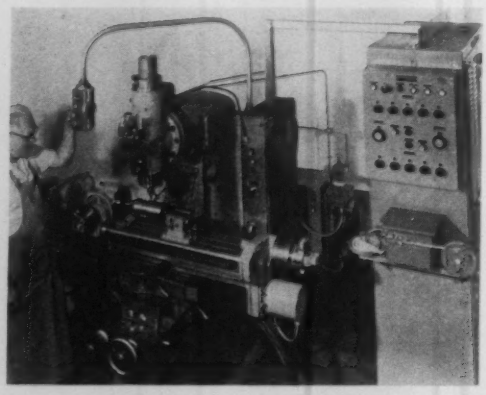
Hydraulic and electric servomechanism systems developed for tracer type controls were a great step forward because they had the ability to smoothly synchronize two or more motions. Developments in numerical control equipment have drawn heavily on the talents and techniques of tracer operations as well as the related areas of aircraft and gunfire control. However, a tracer system must have a template or model of some sort to trace. For many applications this creates a problem since the generation of the required model may require as much time as hand fashioning of the desired workpiece.

Consideration of some of the problems involved in producing two and three-dimensional contours on machine tools led to discussions between Parsons Corp. and the Air Materiel Command, and the historic development of the numerically controlled milling machine at Massachusetts Institute of Technology. Many other developments have also contributed to the technology of synchronizing actions so that today some very precise systems are in full production use.

One of the applications of a relatively simple system of this type is for the continuous flow blending of several ingredients, either solid or liquid. Feeders or pumps supplying individual materials are adjusted to desired rates of operation by instructions on punched cards. Adjustable control of the individual units can produce formulas accurate to one-tenth of one per cent.

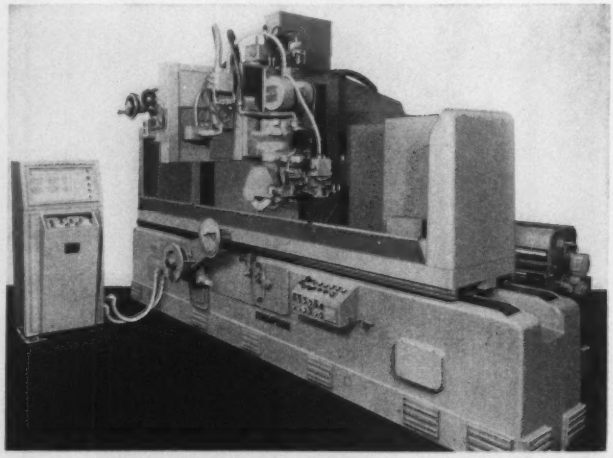
A more sophisticated system is that used to control the spraying of frit on cast iron plumbing fixtures. A magnetic tape controls motions of the manipulator arm as the ceramic glaze material is applied to a variety of shapes and sizes of workpieces. The process requires uniform application of the frit over the entire surface to be treated, and it must be applied to workpieces that are red hot. These factors were prime reasons for the development of equipment to perform the operation under magnetic tape control.

In the production of heavy castings, magnetic tape controls the actions of an automatic sand-



Milling of cylindrical, conical, and flat surface master cams is performed on this machine built by Brown & Sharpe Mfg. Co. with General Electric Co. control. The tape controlled unit will machine hole patterns besides machining contours.

Continuous path contours in vertical and horizontal planes are ground by this Thompson Grinder Co. product. The punched tape control system was built by Thompson Ramo Wooldridge Inc.



slinger that makes medium and large molds. The sandslinger head is automatically moved over a desired path to produce molds consistently rammed in the same manner. This sandslinger and the frit spraying equipment just mentioned use the technique of record-playback in which the equipment is put through a desired cycle under manual control to generate the control tape. Thereafter the tape can automatically reproduce the cycle.

In many cases desired relationships between actions must be mathematically exact, or manual performance of a cycle to generate a tape is not practical or efficient. Where these or other factors are of sufficient importance, the great number of control instructions required for continuously synchronizing desired actions are obtained by calculation. Oftentimes this task is performed by special computing equipment or general purpose computers. At other times it may be performed only with the aid of simple desk type calculators. By whatever method of preparation used, whether remote from the machine or in its control unit, a set of detailed instructions are prepared to guide the actions being controlled.

Such detailed instructions may be brought to the machine on magnetic tape in forms similar to those obtained by recording a cycle performance. A flame profiling machine is one example of a system using calculated instructions on a magnetic tape to continuously synchronize its actions. This particular machine is used to cut large steel plates for shipbuilding and other steel fabrication industries. The plate to be cut remains stationary on a cutting table while the cutting torch is moved over it by continuously synchronized motions along a longitudinal axis and a transverse axis.

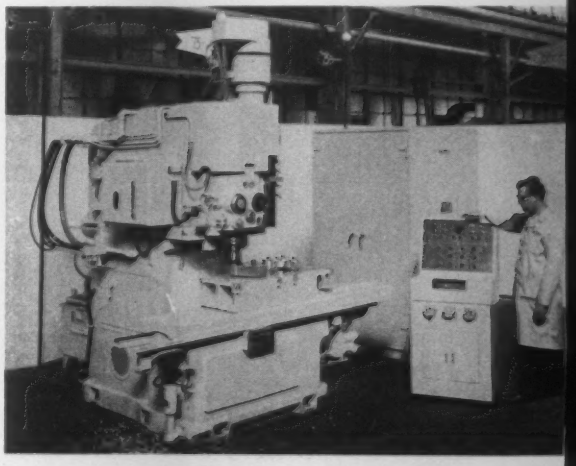
Applications of numerical control for continuous synchronizing of complex operations have undoubtedly been most numerous in the machine tool field. Processing requirements and Government interest have helped lead to truly spectacular equipment in this area. Capabilities have ranged from 2-axis profiling machines, with synchronized motions along two linear axes, to 5-axis contouring machines with synchronized motions along three linear axes and rotation about two axes.

Machines in which the workpiece is rotated about an axis during the operation—turning, grinding, milling—have been developed for continuous synchronizing of motions of two or three axes. For turning of parts which are symmetrical about the axis of rotation, lathes have been built with numerical control of synchronized saddle and cross slide motions. One interesting turret lathe incorporates provision for tape control only of contouring; other programmed instructions are recorded on a magnetic memory which initiates and terminates the tape control phases.

To generate non-symmetrical solid shapes such as three dimensional cams and turbine blades, travel of a saddle, travel of a cross slide, and rotation of the workpiece must be mutually synchronized. One type of machine with such control provisions features interchangeable milling and grinding head assemblies. In one use, turbine blades are milled and ground from forged blanks on this machine. Steam turbine buckets that previously took about five months of tooling time can now be set up in one week. On such a machine, a set of cams for an airfoil milling machine can be produced in 10 days as contrasted to 9 weeks by the previous method. Complex cams that took 40 hours or more to machine by conventional methods are now produced in 8 hours.

Where the workpiece is stationary or has only linear motion during the process, the workhead may require continuously synchronized motions along or about several axes to perform desired milling and grinding operations. In one early machine a large plate to be milled could be mounted against a vertical stationary surface. The milling cutter was mounted on a spindle carried by a saddle on a vertical column. Movements of the machine were synchronized combinations of: 1. Horizontal movement of the column parallel to the workpiece. 2. Vertical movement of the saddle. 3. Movement of

Milling machine built by Kearney & Trecker Corp. performs continuous contouring operations by control of motions along three axes. Punched tape control system was produced by Bendix Corp.



Contour milling by this machine is numerically controlled by parabolic interpolation system. Both machine and control system were manufactured by Cincinnati Milling Machine Co.

the spindle along its axis toward and away from the workpiece. 4. Swiveling of the spindle on the saddle about a horizontal axis parallel to the workpiece. 5. Swiveling of the column about a vertical axis.

In other machines the workpiece is mounted on the vertical face of a table that has linear horizontal motion while the machining head moves perpendicular to the table motion and also up and down. Still other machines mount the workpiece on top of a table that has linear horizontal motion while the machine head can move transversely and vertically above the work. Some of these units handle such large workpieces that sheer size alone is impressive. One skin mill, for example, is a 12-foot by 80-foot unit that can produce integrally-stiffened wing panels under magnetic tape control. Intricate machining operations over the large areas of the workpieces involved would be extremely difficult and expensive to perform accurately under manual control.

Some tremendous improvements in production operations have been reported for manufacture of contoured workpieces. A few examples are noted in TABLE 3 along with some similar examples for systems that only control the limits of mechanical motions. Interesting twists on applications have been in the production of tools to be used in other manufacturing operations—templates and cams for tracer controls and inspection, dies for assembly and forming use.

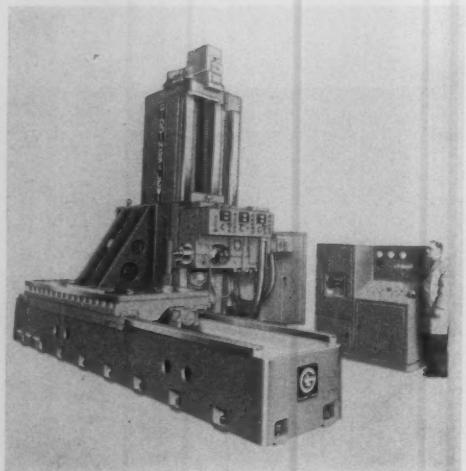
▶ Where From Here?

As the applications just outlined indicate, numerical control is now being used in many types of applications. A single control builder expects to ship his 500th numerical control system in 1960; a single machine tool builder has taken orders to date for at least 150 numerically controlled machines, a great many of them already shipped; and another machine tool builder has shipped some 30 numerically controlled contouring machines alone.

But in a great number of plant operations of the types on which applications have been made, numerical control is conspicuous only by its absence. Further applications in these areas seem natural to expect. Where operating experience is producing proof of effective results in these types of applications, numerical control will surely be applied to more and more operations. A few results reported from use on machine tools are noted in TABLE 3. In this area some comments indicate that 50 per cent of the machine tools sold in 1965 may be numerically controlled.

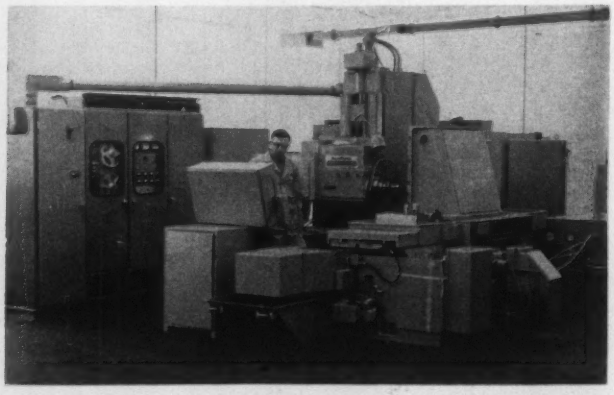
A survey conducted by AUTOMATION shows that builders of numerical control systems do not believe that future applications will be limited to increased saturation of past types of applications. In TABLE 4 are listed additional types of applications envisioned by control builders for their own equipment. The fact that some control makers see new applications of their equipment in areas already using equipment built by others is confirmation of the trend to also further saturate present application areas.

Why have past applications been made, and what might be expected to lead to further applications? For bona fide use in the manufacturing world, numerical control must pass the universal test—advantages must exceed disadvantages. Considerations involved are those already discussed and those noted in the boxes accompanying this article. Consensus, of people informed on the subject, appears to be that advantages will exceed disadvantages and lead to further use of numerical control in manufacturing.



Die sinking and contour milling are performed under magnetic tape control on horizontal spindle machine. Basic machine and control system supplied by Giddings & Lewis Machine Tool Co.

Punched tape control of three-dimensional contour milling is incorporated in this machine built by Pratt & Whitney Co. Inc. The control system was built by Bendix Corp.



Companies Active in Numerical Control

Advance Industries Inc.; Cambridge, Mass. Positioning controls for one and two-axis applications. Controls have been applied to locating table for drill press and eyeletting machine. Punched tape of special width stores input commands.

Aero Service Corp.; Philadelphia, Pa. Co-ordinate plotter that accepts input data punched into cards or tape. Instrument applied in lofting type applications, printed circuit layout, and inspection operations.

American Tool Works Co.; Cincinnati, Ohio. Tape controlled positioning table. Unit can be applied with radial drill and special adaptations to achieve jig borer accuracies. Punched tape control unit is manufactured by Sperry Gyroscope Co., Canada Ltd. Also 6-spindle turret-type drilling, tapping, and boring machine controlled by punched tape.

American Type Founders Co. Inc.; Elizabeth, N. J. For text composition, have developed typesetter that is programmed by 7-channel punched tape.

Autonetics, Div. of North American Aviation Inc.; Downey, Calif. Contouring control system utilizing 7 or 8-level punched tape for command inputs. Capable of controlling all types and sizes of milling machines, lathes, forming machines, die sinking machines, and inspection equipment.

Avey Div., Motch & Merryweather Machinery Co.; Cincinnati, Ohio. Multiple spindle turret type drilling machine which can be supplied with numerically controlled positioning table. Have applied punched tape control systems manufactured by several companies.

Baker Bros. Inc.; Toledo, Ohio. Several numerically controlled machine tools including special machine that performs drilling, reaming, tapping, and spot milling on large generator rotors under General Electric Co. tape control. Single spindle drilling machine and circular work table that is controlled with system furnished by Farrand Controls Inc.

Barnes Drill Co.; Rockford, Ill. Several numerically controlled drilling machines, including unit in which four motions can be programmed. Controls furnished by General Electric Co. have been used.

Beardsley & Piper Div., Pettibone Mulliken Corp.; Chicago, Ill. Automatic sandslinger capable of reproducing movements which give optimum ramming of molds. Record-playback technique used to program magnetic tape controlled unit. Controls furnished by Micro-Path Inc.

Bendix Corp.; Detroit, Mich. Two contouring systems controlled by punched tape and one contouring system controlled by magnetic tape. Controls have been applied to profile and contour milling machine, rotary milling machines, boring machines, jig borers, template grinding machines, turbine-blade milling machines, inspection machines, drilling machines, and lathes.

Borg-Warner Research Center; Des Plaines, Ill. Have designed program-controlled manipulator arm that utilizes magnetic tape to store command signals. Record-playback technique used in programming.

Brown & Sharpe Mfg. Co.; Providence, R. I. Vertical milling machine, particularly suited to milling cams. Have also developed numerically controlled position table for current drilling machine. General Electric Co. two-axis controls, utilizing 8-level tape, are used.

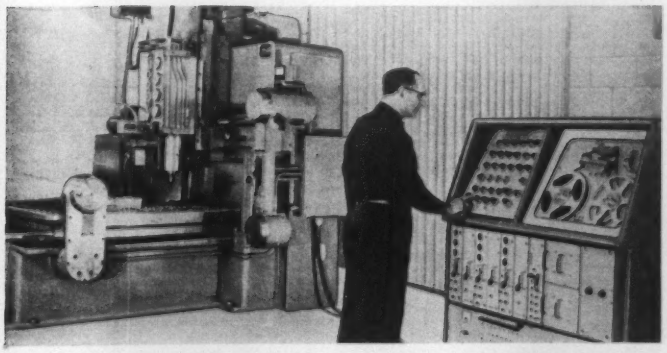
Bullard Co.; Bridgeport, Conn. Tape controlled horizontal boring mill. General Electric Co. control systems are applied to units.

Burg Tool Mfg. Co. Inc.; Gardena, Calif. Six and eight-spindle turret drills operated by punched tape control. Various manufacturers have furnished control systems, including Hughes Industrial Systems Div. and General Electric Co.

California Technical Industries; Belmont, Calif. Line of component and circuit testing equipment which is programmed by punched cards and punched tape.

Carlton Controls Corp.; Worcester, Mass. Point-to-point control system that uses 8-level punched tape. Controls have been applied to drilling and boring machines.

Carlton Machine Tool Co.; Cincinnati, Ohio. Vertical drilling and boring machine equipped with positioning table that is numerically controlled.



Three-axis contouring control is feature of this planer type milling machine built by Morey Machine Tool Co. Inc. The magnetic tape control system was supplied by Stromberg Carlson, Div., General Dynamics Corp.

Cincinnati Lathe and Tool Co.; Cincinntai, Ohio. Numerically controlled lathe and a drilling machine equipped with numerically controlled positioning table. The punched-tape control systems are furnished by Cincinnati Milling Machine Co.

Cincinnati Milling Machine Co.; Cincinnati, Ohio. Equipment manufacturer has developed both contouring and point-to-point control systems based upon data input by punched card and punched tape. Contouring controls utilizing punched card input of data have been applied to various milling machines. Among other types of numerical controlled machine tools offered are lathes and positioning tables.

Cleereman Machine Tool Corp.; Green Bay, Wis. Has applied General Electric Co. punched tape control system to layout drilling machine.

Consolidated Avionics Corp.; Westbury, N. Y. Designs and manufactures automatic electronic testing and checkout systems which can be programmed.

Consolidated Machine Tool Div., Farrel-Birmingham Co. Inc.; Rochester, N. Y. Developed a dual head cavity milling machine which can be supplied with magnetic tape controls.

De Vlieg Machine Co.; Royal Oak, Mich. Programmed jig mills. One series is controlled by 8-level punched tape; another series is controlled by manual manipulation of dials. Both control systems provide for point-to-point positioning.

Electric Controller & Mfg. Co., Div. Square D Co.; Cleveland, Ohio. Programmed mill roll-opening control system in which data is stored on special-sized punched card.

Electronic Control Systems, Div. of Stromberg-Carlson Co.; Los Angeles, Calif. Control system for contouring applications that can also be adapted to positioning control. Input data is stored on 8-level punched tape. System has been applied to various contour milling machines, including those manufactured by Kearney & Trecker and Morey Machinery Co. Company offers 2-axis positioning table which utilizes punched tape control.

Ex-Cell-O Corp.; Detroit, Mich. Variety of precision and special machine tools to which numerical controls of customer's choice are applied. Have used control systems built by companies such as Bendix Corp. and General Electric Co. for grinding, turning, boring, and milling applications.

Fairbanks Morse & Co.; Chicago, Ill. Automatic batching equipment in which input data is stored on punched cards.

Farnham Div., Weisner-Rapp Co.; Buffalo, N. Y. Have developed magnetic tape controlled contouring system retrofitted to template maker. Control system can be applied to spar mills manufactured by company.

Farrand Controls Inc.; New York, N. Y. Punched-tape (8-level) positioning control systems. Controls have been applied to vertical jig borers, horizontal boring machines, drilling machines, rotary tables, spot welding machines, and various special machines.

Ferranti, Ltd.; Detroit, Mich. Punched tape positioning control system and magnetic tape contouring control system. These British systems are distributed in U. S. by Bendix Corp.

Fosdick Machine Tool Co.; Cincinnati, Ohio. Equipment manufacturer offers jig borer that can be controlled by either IBM punched cards or 8-level punched tape. Have developed application involving automatic rotary tool changer capable of storing 30 cutting tools. Radial layout machine has been built, using General Electric Co. controls.

Friden Inc., Commercial Controls Corp., Subsidiary; Rochester, N. Y. Prominent in numerical control field, supplying typewriters actuated by punched media and various equipment items to prepare punched media.

G. A. Gray Co.; Cincinnati, Ohio. Modular form of punched tape controls for horizontal boring and milling machines, and planer type milling machines. Norden Div., United Aircraft Corp. manufacturers controls.

Gardner-Denver Co.; Quincy, Ill. Have developed automatic machine for wrapping two ends of interconnecting wiring simultaneously to separate terminals. Machine can be directed by either punched cards or punched tape.

Gemco Electric Co.; Detroit, Mich. Various types of controls that utilize punched tape input, programming boards, or programming switches. Systems used for positioning, programming, batching, and regulating forms of control. Have been applied to such equipment as boring and milling machines, drilling machines, batching operations, shears, piercing machines, and testing operations.

General Electric Co., Specialty Control Dept.; Waynesboro, Va. Positioning controls actuated by 8-channel punched tape; two forms of contouring controls offered, one utilizing 8-level punched tape for data input, the other 14-channel magnetic tape. Company's controls have been applied to bending machines, boring machines, co-ordinate tables, drilling machines, flame cutting machines, lathes, milling machines, punch presses, rotary tables, shapers, welding machines, and testing and inspection equipment. Company has also developed other forms of numerical control, such as card control of screw-down for rolling mills.

General Electro-Mechanical Corp.; Buffalo, N. Y. In conjunction with several airframe manufacturers developed large drilling and riveting machines. Both punched card systems and punched 35 mm film systems have been described.

Giddings & Lewis Machine Tool Co.; Fond du Lac, Wis. Both continuous path (magnetic tape input) and point-to-point control systems (punched tape input). Equipment supplied with numerical controls includes table-type and floor-type horizontal boring, drilling, and milling machines; vertical turret lathes; vertical boring mills; planer mills; skin and spar milling machines; multiaxis, horizontal, contour milling machine; positioning tables, and horizontal jig borers.

Gisholt Machine Co.; Madison, Wis. Machines with positioning and program controls; turret lathes capable of contour turning and contour boring under magnetic tape control. Self-manufactured magnetic tape control system uses 2¼-inch wide tape that is prepared on small, special purpose analog computing and recording unit.

Hamilton Div., Baldwin-Lima-Hamilton Corp.; Philadelphia, Pa. Developed special tail-pipe bending machine in co-operation with

General Electric Co., whose punched tape control system was used.

Heald Machine Co.; Worcester, Mass. Precision machines capable of performing both contour boring and contour turning operations. Various control systems have been applied to the machine tools.

Heltzel Steel Form and Iron Co.; Warren, Ohio. Component and equipment items which can be combined with scales to form engineered batch-weighing systems. Input commands are stored on IBM punched cards.

Walter P. Hill Co.; Detroit, Mich. Special drilling machines which have been equipped with 8-level punched tape control units manufactured by General Electric Co.

Hillyer Corp.; Cranford, N. J. Point-to-point positioning, control system and programming components. Control system employs either 8-level punched tape or special 140-level punched plastic tape. Controls have been applied to milling, drilling, tapping, and boring machines; tubesheet machines; printed circuit machines; photo composing machines; and punch presses.

Howe Scale Co.; Rutland, Vt. Active in batch weighing field, supplying variety of equipment items necessary for automatic systems.

Hughes, Industrial Systems Div.; Los Angeles, Calif. Positioning control systems that utilize 8-level punched tape input. Modularized control has been applied to drilling machines, turret drills, circuit board drills, punching machines, positioning tables, and boring machines.

International Business Machines Corp.; Endicott, N. Y. For self-use have designed and applied variety of numerically controlled equipment. Particularly active in programmed assembly machines. Active in developing simplified programming routines and techniques for IBM computers used in establishing contouring programs.

Jones & Lamson Machine Co.; Springfield, Vt. Positioning and programming controls applied to turret lathes and drill tables. Punched tape input is on 8-level tape. Controls have been applied to turret lathes, drill tables, inspection machines, punch presses, and horizontal boring machines.

Jordan Controls Inc.; Milwaukee, Wis. Variety of control forms based upon punched cards, punched tape, or dial input of data. Such control forms have been applied to drilling machines, boring machines, bending machines, grinding machines, printing machinery, atomic reactors, feed mill blending equipment, and on-line petroleum blending.

Kearney & Trecker Corp.; Milwaukee, Wis. Included in line of 10 machine types are 3 and 4-axis profilers, multiple head skin and spar mills, and versatile horizontal spindle machines capable of milling, drilling, boring, reaming, and tapping. Latter unit is provided with automatic tool changing capability. Numerical controls have been supplied by various companies, including General Electric Co. and Bendix Corp.

Lahr Machine & Tool Corp.; Toledo, Ohio. Target drilling machine that is controlled by punched tape. Controls for unit furnished by Control Instrument Div., Warner & Swasey Co.

Leland-Gifford Co.; Worcester, Mass. Has adapted tape controls to two-spindle machine for drilling electronic circuit boards and to a general purpose drilling machine of same type.

Linde Co., Div. of Union Carbide Corp.; New York, N. Y. With co-operation of Farrand Controls Corp. and Welding Machine Div., Expert Die & Tool Co., company has built tape-controlled, multiple-torch Heliarc spot welding machine.

Lucas Machine Div., New Britain Machine Co.; Cleveland, Ohio. Variety of tape controlled machine tools, including vertical spindle machine for drilling, milling, and tapping operations with tools that are automatically changed under tape control. General Electric Co. control systems are applied to company's line.

McKay Machine Co.; Youngstown, Ohio. Has applied point-to-point positioning control in special drilling machine to move drill heads over large-size workpieces. Control information is stored on punched tape.

Mergenthaler Linotype Co.; Brooklyn, N. Y. Unique system for setting and making-up type for printing that is controlled by 15-level punched tape.

Micro-Path Inc., Subsidiary of United Industrial Corp.; Los Angeles, Calif. Control system that can be applied to point-to-point positioning and two-axis contouring applications. Data input is by means of 11-channel magnetic tape. Record-playback technique is used to prepare magnetic tape. Controls have been applied to such equipment as positioning table and automatic sandslinger.

Monarch Machine Tool Co.; Sidney, Ohio. Lathes equipped with positioning controls for turning, facing, and boring operations. Have used General Electric Co. punched-tape control units.

Moog Servocontrols Inc.; Industrial Div.; East Aurora, N. Y. Has prototype point-to-point positioning control system, actuated by punched tape, that uses no electrical components. Entire system is based on pneumatic-hydraulic components and techniques.

Morey Machine Tool Co. Inc.; New York, N. Y. Profile milling machines programmed by magnetic tape. Contouring control of 3-axis motion has been provided by systems built by Bendix Corp., General Electric Co., and Electronic Control Systems.

Morton Mfg. Co.; Muskegon Hts., Mich. Large vertical boring machine in which vertical and radial tool positions are numerically controlled. General Electric Co. control system is used.

National Automatic Tool Co. Inc.; Richmond, Ind. Equipment manufacturer has developed 8-level punched tape control system for point-to-point positioning. System can provide necessary control of auxiliary functions, including tool-changing. Controls have been applied to various drilling and boring machines.

National Electric Welding Machines Co.; Bay City, Mich. Has adapted numerical controls to automatic welding machines, both arc and resistance types. Also constructed cable forming machine that forms harnesses under punched tape control.

Norden Div., United Aircraft Corp., Data Systems Dept.; Costa Mesa, Calif. Controls applicable to measuring, positioning, and inspection operations. Systems use 8-level punched tape. Controls have been applied to jig borers, drilling tables, rotary indexing tables, horizontal boring machines, milling machines, and layout drilling tables.

Potter & Johnston Co.; West Hartford, Conn. Tape control as optional feature for line of automatic turret lathes. Motions are controlled by 7-channel punched tape that is prepared on special punching equipment.

Pratt & Whitney Inc.; West Hartford, Conn. Several types of numerically controlled machine tools. Company has applied own punch tape control to line of jig borers, hole grinders, and rotary tables. Bendix Corp. contouring control has been applied to horizontal spindle milling machine.

Reliance Electric & Engineering Co.; Cleveland, Ohio. Point-to-point positioning control systems, including two-axis and three-axis forms. Input data stored on 8-level punched tape. Has been applied to several drilling machines.

Rheem Mfg. Co., Electronics Div.; Los Angeles, Calif. Positioning control system based upon 8-level punched tape input. Control system has been applied to multispindle precision boring machine.

Richardson Scale Co.; Clifton, N. J. Company offers punched card controlled weighing and batching systems.

Seneca Falls Machine Co.; Seneca Falls, N. Y. Control systems for machines or processes requiring position and speed control. Data input to controls is by punched tape and manually set dials. Controls have been applied to lathes, boring mills, 2-axis positioning tables (both point-to-point and contouring), dynamic testing machines, and glass process machines.

Simmons Machine Tool Corp.; Albany, N. Y. In conjunction with General Electric Co., whose controls are used, have built large multiaxis conductor-bar milling machine.

Sperry Gyroscope Co. of Canada Ltd.; Montreal, Canada. Point-to-point positioning control system utilizing 8-level punched tape input. Control system has been applied to jig borers, horizontal boring mills, positioning tables, turret drills, turret punch presses, and radial drills.

Swift Ohio Corp.; Kenton, Ohio. Manufacture machine tools and welding equipment for use in conjunction with numerical controls. Package positioning controls offered by most manufacturers can be used.

Square D Co., Industrial Controller Div.; Milwaukee, Wis. Control systems which can accept data stored on punched cards or punched tape.

Standard Electrical Tool Co.; Cincinnati, Ohio. Precision 2-axis positioning tables to which numerical control systems (such as General Electric Co.) have been applied in developing custom-built machines.

Sundstrand Machine Tool Div., Sundstrand Corp.; Belvidere, Ill. Several forms of numerically controlled machine tools, including horizontal drilling machine. Units equipped with General Electric Co. punched tape positioning controls. Company's numerically controlled positioning table has been applied to other manufacturers' machine tools and to development of special machine tools.

Tape Control Corp.; Glenview, Ill. Variety of control systems including contouring, positioning, and programming types. As prototype, have developed system that is programmed by playback technique. Input information stored on 5, 6, 7, or 8-level punched tape. Controls have been applied to vertical milling machines, industrial wood and aluminum routers, and various special purpose machines.

Teletype Corp., Subsidiary Western Electric Co. Inc.; Chicago, Ill. Communications equipment actuated by punched tape and variety of components which can be applied to data processing, communications, and control systems.

Thayer Scale Corp.; Pembroke, Mass. Batching equipment utilizing servo control techniques to obtain desired feed rate during discharge.

Thompson Grinder Co.; Springfield, Ohio. Grinder which is capable of grinding contours in both vertical and horizontal planes. Control system is manufactured by Thompson Ramo Wooldridge Inc. and utilizes 8-level tape for data input.

Thompson Ramo Wooldridge Inc.; Cleveland, Ohio. Punched tape (7-level) control system for guidance of four machine axes. Have described applications on Cincinnati milling machine. Three-axes control system applied to contour grinding machine.

Toledo Scale Div., Toledo Scale Corp.; Toledo, Ohio. Automatic batching equipment in which data is stored on interchangeable plugboards.

True Trace Sales Corp.; El Monte, Calif. Continuous path control system based on magnetic tape input of data. True Trace-ACA (Automation Corp. of America) system has been retrofitted to Gorton vertical milling machine among others.

Wang Laboratories Inc.; Natick, Mass. Position control systems with punched tape and manually set dials for data input. Controls have been applied to milling machines and drilling machines. Punch tape block reader is offered as separate item and has been used in various tape control applications.

Warner & Swasey Co.; Cleveland, Ohio. Machine tools equipped with numerical controls and, through Control Instrument Div., several types of tape control systems for point-to-point positioning. Has demonstrated turret lathe that can be programmed by record-playback technique; punched tape control of contouring is feature of control system. Separate control systems offered have been applied by various companies to range of equipment items, including inspection machines and precision boring machines.

Western Electric Co. Inc.; Kearny, N. J. For self-use has developed variety of numerically controlled manufacturing equipment. Examples include punched tape controlled testing machines and wire-wrapping machines used in assembly operations.

Westinghouse Electric Corp., Systems Control Dept.; Buffalo, N. Y. Positioning and programming control systems that utilize 8-level punched tape for data input. The transistorized controls have been applied to lathes, jig borers, milling machines, and press feed lines. Company is prominent in industrial field, supplying punched card controls for screw-down drives in steel mills and similar programming requirements.

Wiedemann Machine Co.; King of Prussia, Pa. Turret type punch presses equipped with General Electric Co. tape control systems; motions along three axes are controlled.

WELDING HEAT EXCHANGER SECTIONS

INSTALLATION of two automatic carbon dioxide shielded arc welding machines at Lennox Industries Inc. has reduced considerably the fabrication time for welding gas-fired heat exchanger sections. One machine welds sections made of plain carbon steel, and the other unit processes sections formed from corrosion resistant aluminized steel, *Fig.* 1.

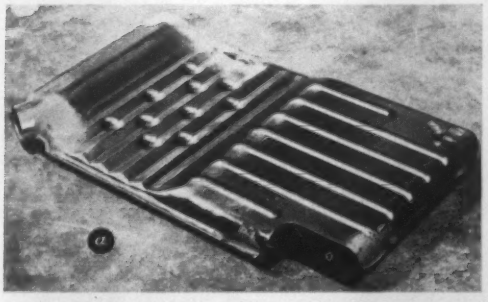
A heat exchanger section is composed of a right-hand and a lefthand die-pressed stamping. Prior to machine welding, baffleplates and spacers are manually tack welded to each stamping. Then the two stampings are positioned in a fixture on the automatic welding machine, and a pneumatic cylinder is actuated to close the fixture. The fixture is designed so that in its closed position only the edges to be welded are exposed.

After manual loading, the machine, *Fig.* 2, operates automatically as it edge welds four sides of the rectangular heat exchanger section. Each side of the section requires a different length of weld due to the rectangular shape of the part and to several openings in the unit. The welding head on the machine is controlled so that it starts and stops the welding operation at the proper time to compensate for the different weld lengths. After each side is welded, the fixture is automatically rotated 90 degrees, and the weld cycle is repeated. To eliminate wasted time, the weld head does not return to a home position after each weld. Welding is done in both directions, and if the first weld is from left to right, then the second weld will be made from right to left.

Each aluminized steel exchanger section requires a total of 78 inches of weld, and 81 inches of weld are used on the carbon steel exchanger units. Welding speeds are 42 inches per minute for the aluminized steel and 53 inches per minute for the carbon steel units.

After the automatic welding cycle is completed, the operator removes the welded part from the fixture and places it in a nearby hand operated positioner. He then reloads the automatic machine and starts the weld cycle for the new part. While the machine is welding this part, the operator completes the welding operation on the unloaded part by adding short corner welds and welds adjacent to the openings in the section.

The two welding machines were built by the World Electric Co. and use carbon dioxide welding heads, controls, and constant voltage welders provided by Hobart Bros. Co.



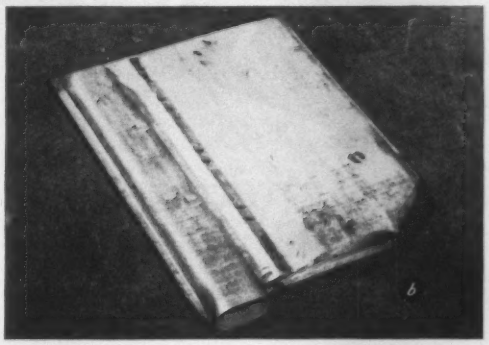


Fig. 1—These two types of heat exchanger sections are welded on automatic carbon dioxide shielded arc machines. Plain carbon steel section *(a)* requires a total of 81 inches of weld and is processed at a welding speed of 53 inches per minute. Aluminized steel section *(b)* is more difficult to weld, requires a total of 78 inches of weld, and is fabricated at a welding speed of 42 inches per minute.

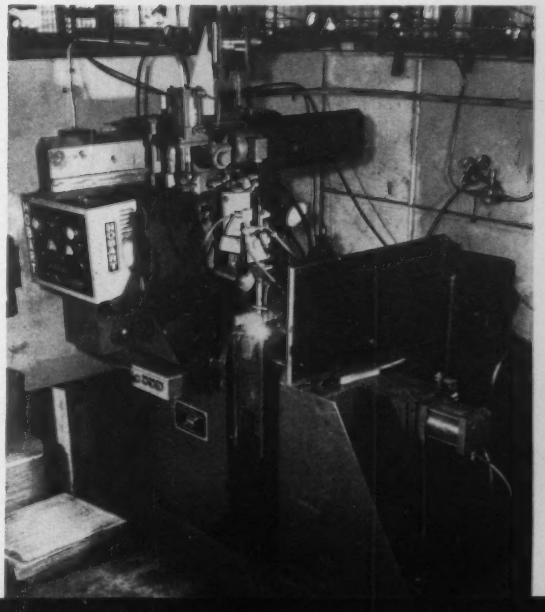
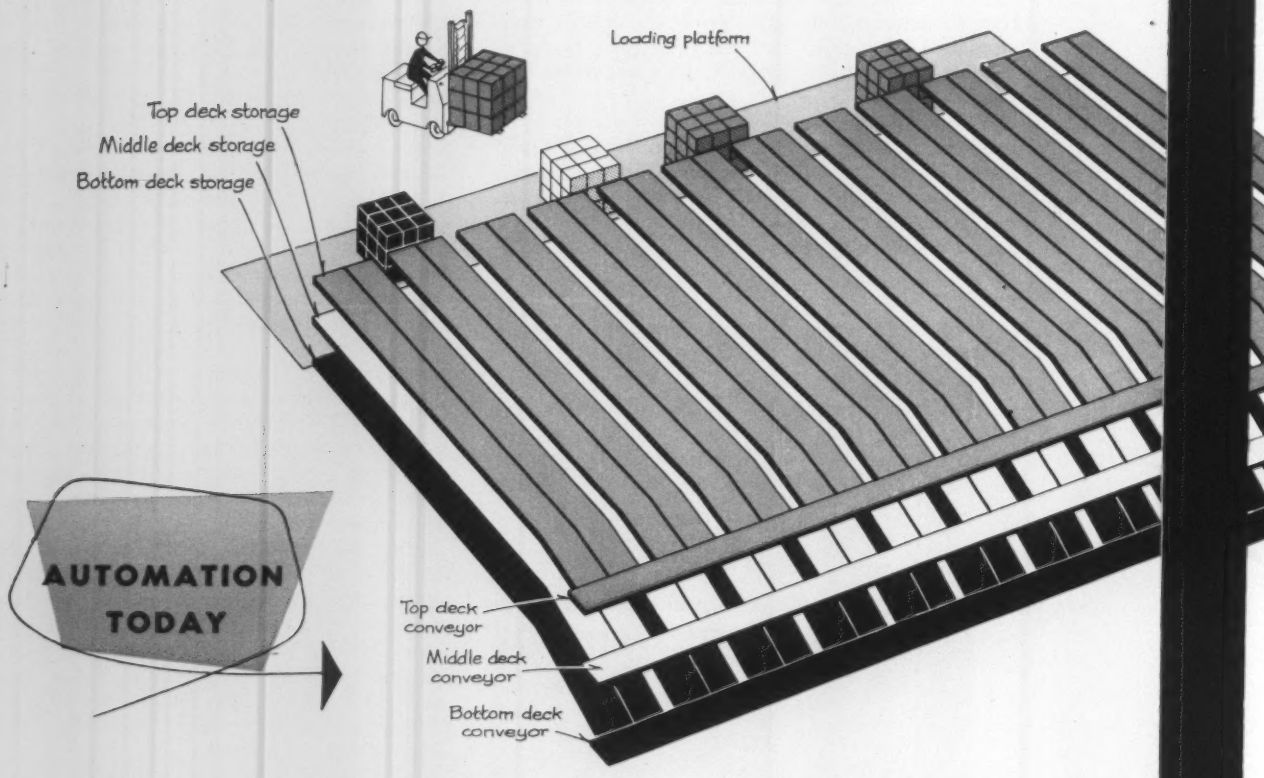


Fig. 2—This view shows one of the two automatic welding machines. An aluminized steel heat exchanger section is positioned in the machine fixture and is being edge welded on one of its four sides. When the weld on this side is completed, the fixture and part will be rotated 90 degrees for the next weld cycle. To save time, the weld head does not return to home position after each weld cycle. Instead, if one weld is made from left to right, the next weld will be made from right to left.

1 Diagram illustrates the flow of toilet article cartons in a punched card controlled handling system at a distribution center of Colgate-Palmolive Co. The 72 most active products are stored in the three-deck automatic selection system on the left. Less active products are stored and manually picked from the conveyor rack and shelf areas in the center. Coded tote boxes lead each carton train to the truck dock conveyors on the right.

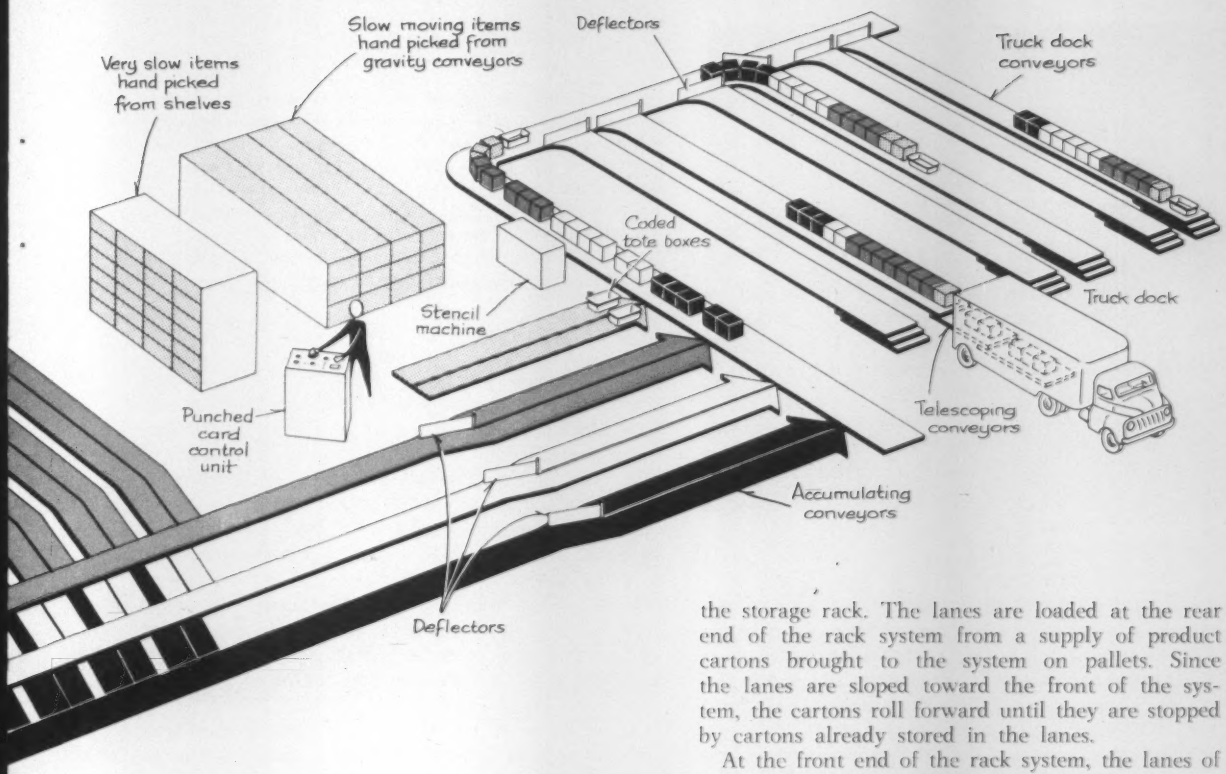


PUNCHED CARD CONTROL ACTUATES

MECHANIZED ORDER-PICKING SYSTEM

WHEN current sales levels call for selecting and shipping an average of 9000 cartons of a variety of products each day, automatic order-picking and carton handling facilities become almost a necessity to keep abreast of demand. Such is the case at a large distribution center of Colgate-Palmolive Co. in Kansas City, Kans., where orders are filled for customers who do business in a territory stretching from Illinois to Texas. To increase the speed and accuracy of filling carton orders for its line of toilet articles, the company has recently installed an electronically controlled, punched card order-picking system.

Since slow-moving items seldom justify the cost of equipment to pick them automatically, the system is a combination of automatic and manual picking methods. Eighty per cent of the distribution center's shipping volume consists of 72 fast-moving products which are selected automatically by means of punched cards and electronic control. Twenty per cent of the shipping volume is picked by hand from two storage rack systems. Of this latter percentage, 130 slower-moving items are stored on tiered gravity roller conveyors that feed cartons

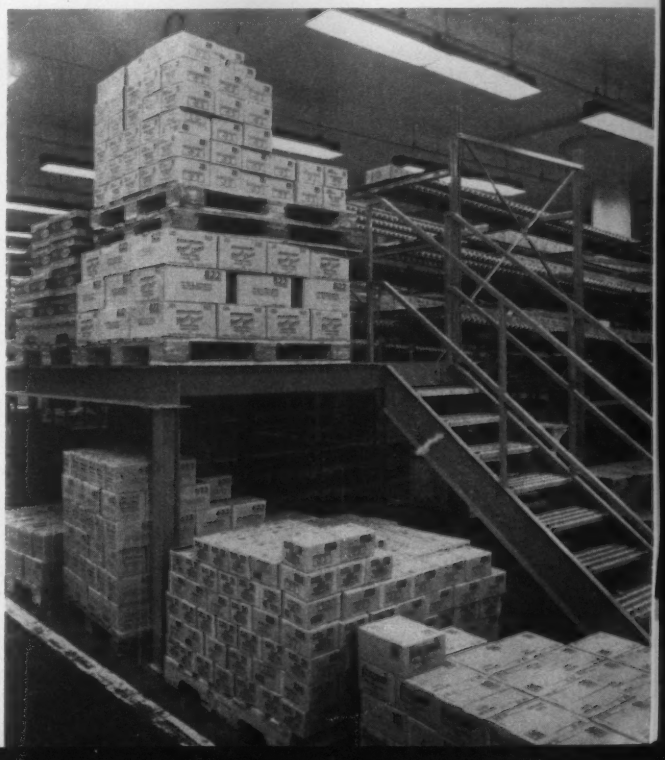


forward as an operator removes cartons for an order. Occasional demand items, approximately 35 in number, are stored on shelves and are also selected manually by the operator.

The order-picking operation has been designed to be compatible with an existing punched card billing and inventory control system in use at the center. Each order is first broken down into fast-moving items, slow-moving items, and occasional demand items. For the fast-moving items, a punched card is prepared for each individual product listed. This card lists the number of cartons required to fill the order and may call for 1 to 99 cartons of a particular product. The cards are assembled in random order into a deck, and a special "end-of-order" punched card is placed on the bottom of the deck. Slow-moving and occasional demand items are listed on a separate tally sheet, and both the card deck and the tally sheet are delivered to the system operator.

Cartons of fast-moving items are stored in a large gravity roller storage rack which is arranged in three decks, each deck having 24 lanes for cartons. A different product is stored in each of the 72 lanes of the storage rack. The lanes are loaded at the rear end of the rack system from a supply of product cartons brought to the system on pallets. Since the lanes are sloped toward the front of the system, the cartons roll forward until they are stopped by cartons already stored in the lanes.

At the front end of the rack system, the lanes of each deck feed onto one of three belt conveyors which run transversely across the end of the system. Normally, cartons are withheld from these conveyors by stop bars. However, when punched card data has been entered into the control system and calls for a carton from a particular lane, a solenoid valve actuates a pneumatic cylinder which causes the



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Product cartons are loaded onto the gravity roller conveyor lanes of the automatic selection system at the rear of the unit. Each lane holds cartons of one particular product. At the present time, the distribution center is handling 9000 cartons per day.

3

For each customer order, the system operator receives a deck of punched cards containing control data for releasing cartons from the automatic selection racks and a printed list of slow-moving items that must be hand picked. The card reader in the control console scans the deck of cards and accumulates carton release information in a memory circuit. This information is fed in a pre-established sequence to the various gate mechanisms at the selected product storage lanes.

lead carton in the lane to be lifted over the stop bar. The selected carton then rolls onto the transverse belt conveyor for transport to an order accumulating conveyor. A secondary stop bar, also actuated by the pneumatic cylinder, prevents other cartons from following the selected carton.

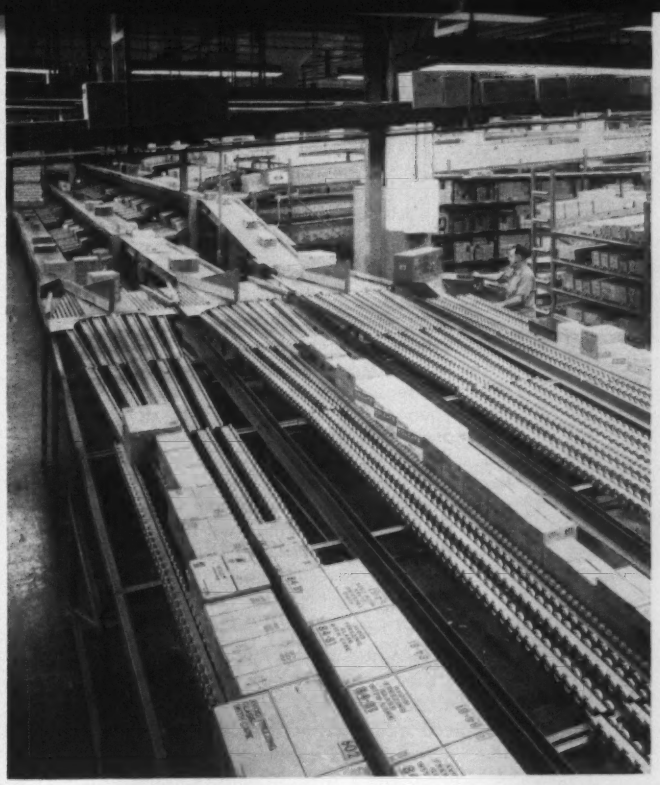
During its movement to the belt conveyor, the selected carton interrupts a photoelectric beam. When the rear of the carton clears the beam, the solenoid valve is released, allowing the remaining cartons in the lane to move forward to the first stop bar. The sequence is repeated until the proper number of cartons has been released from the lane.

As the cartons are selected, they are carried by the three belt conveyors to accumulating conveyors. Each accumulating conveyor consists of a right and a left lane so that as one lane is accumulating cartons for an order, the other lane can be discharging cartons to the shipping area. Movement of cartons from the belt conveyors into the proper accumulating conveyor lanes is controlled by deflector blades whose positions are alternated by the control system after each order-picking cycle.

In addition to the three accumulating conveyors for the automatic selection system, there is also an accumulating conveyor with right and left lanes for manually selected cartons. This conveyor is

4

The automatic selection system is composed of three decks of conveyor storage lanes, each deck having 24 lanes. Over-all view of the system shows product cartons being released to belt conveyors for movement to the accumulating conveyors in the upper right background. Each punched card in an order deck controls the release of one or more cartons from a particular product lane. Cartons are released in a pre-established sequence so as to avoid pile-ups and jams. The system is capable of automatically selecting cartons at a rate of 50 cases per minute or faster.



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The selected cartons are moved by the belt conveyors in the left background onto the accumulating conveyors in the foreground. Each belt conveyor feeds cartons into either of two accumulating lanes depending upon the position of the carton deflectors in the center of the picture. The pair of accumulating conveyors on the right is used by the operator to assemble the lead carton train items consisting of a coded tote box and the manually selected cartons. A carton train will consist of the lead tote box and its following hand picked items, and all of the cartons accumulated in either the right or the left lanes of the three dual-lane accumulating conveyors.

6

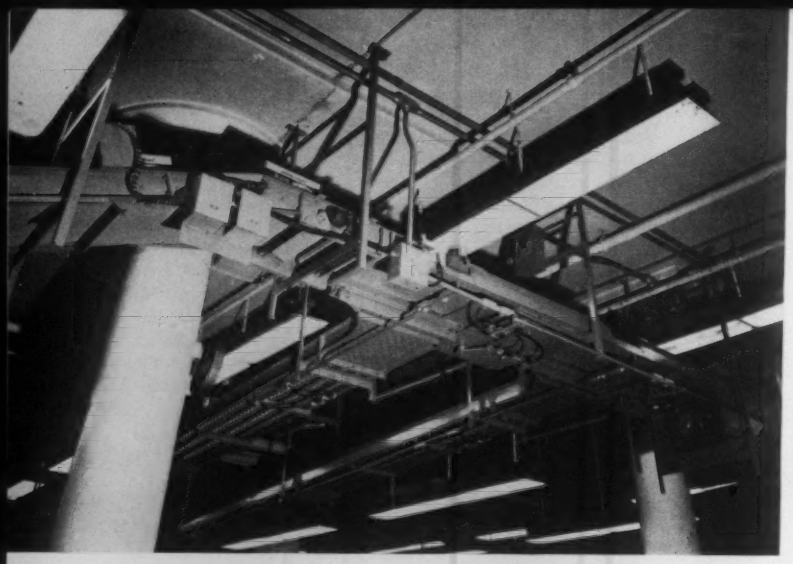
Upon signal from the control unit, the accumulating conveyors discharge their cartons onto a single belt conveyor leading to the truck dock conveyors. The customer name and address is stenciled on the cartons as the conveyor moves the units to the rear of the selection system. Then the conveyor makes a 90-degree turn, shown in this view, and lifts the cartons over the selection racks to the deflectors of the truck dock conveyors.

parallel to the other lanes and is adjacent to the operator's control panel and the storage units for slow-moving and occasional demand items.

When the operator is ready to process an order, he has received a deck of punched cards for the automatically selected cartons, a printed list for the manually selected items, and the number of the truck dock from which the order will be shipped. His first action is to select a lead tote box which is coded to guide the accumulated carton "train" to the designated truck dock. A signal light indicates which lane of the manual accumulating conveyor will be used to hold this order, and the operator places the coded tote box at the head of this lane. He then inserts the deck of punched cards into a card reader in the control console and presses a *Select* pushbutton. While the fast-moving items are being automatically selected and accumulated, the operator hand picks the slow-moving and occasional demand items and places them behind the coded tote box. Less than case lot items are placed in the tote box.

The card reader scans the punched cards at a rate of 100 cards per minute. Cards need not be sorted or placed in the reader in any particular sequence. Data read from the cards are momentarily stored in a memory circuit, sorted as to product locations in the racks, and then released to the automatic selection system in a pre-established sequence. Cartons are selected at a rate of 50 per minute in an order that avoids pile-ups and jams.

As soon as an order has been assembled, the control system releases the cartons from the accumulating conveyors. The conveyor holding the coded tote box and manually selected cartons is released first, and these items move onto a belt conveyor leading to the truck dock. Following these items in the train are the cartons from the top deck, middle



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View taken from below shows the overhead junction of the distributing conveyor with two of the six truck dock conveyor lanes. Markings on the lead tote box are sensed by a detector which causes one of the six deflectors to actuate and guide the carton train down the selected truck dock lane. The deflectors are pneumatically operated by air cylinders and automatically close when the last carton in the train has entered the conveyor lane.

deck, and bottom deck accumulating conveyors. The cartons are stenciled with the name and address of the customer as they move toward the truck dock.

The truck dock is designed so that six trucks can be loading at the same time. Each truck position is fed by a spur conveyor leading off the main conveyor from the selecting area. As the coded tote box leading the carton train nears its designated shipping lane, it causes a deflector blade to actuate across the main conveyor and switch the carton train into the spur conveyor. When the last carton in the train clears the deflector, the unit closes so that following trains may pass if necessary.

The carton train stops on the spur conveyor until a truck is ready to be loaded. Wheeled conveyor sections at the truck end of the spur conveyor are extended into the truck body to facilitate loading. A pushbutton station on the leading extended section allows the loading operator to control the flow of cartons into the truck. As the truck is loaded, the wheeled sections can be gradually retracted toward the spur conveyor so that the loader operator always has ready access to the cartons.

In addition to speed and accuracy in filling customer orders, the high-speed selection and handling system provides closer control over inventory, safer handling of cartons, and considerable savings in warehousing costs. The system will handle a variety of carton sizes ranging from 7 x 6 x 5 inches to 18 x 18 x 8 inches. Normal changes in carton sizes, such as would occur when a new product is stored in a selection lane, can be accommodated without any alteration of the handling equipment. Because of the constantly changing packaging and merchandizing needs of the company, this flexibility is an extremely important factor. All conveyor and rack equipment was designed and built by Alvey-Ferguson Co., and the punched card control system was developed by the Industry Control Dept., General Electric Co.

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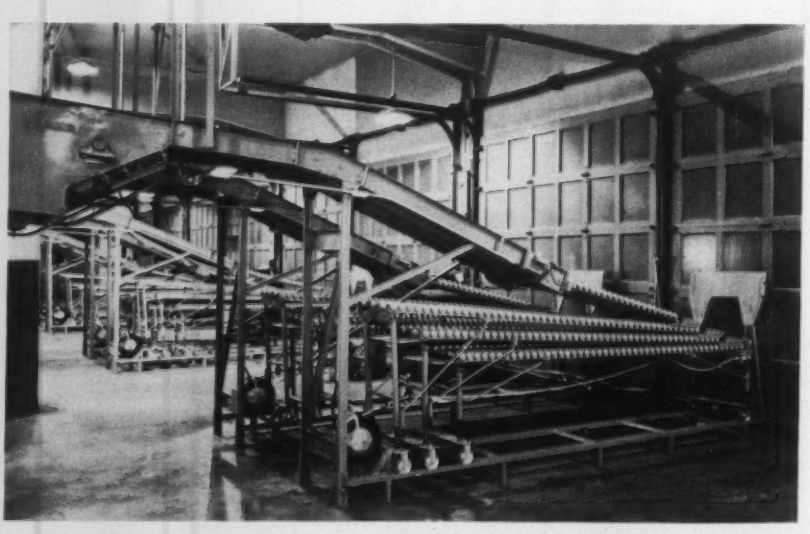
The carton train remains on the truck dock conveyor until a truck is ready to be loaded. Then, the dock doors are raised, the ramp at the front of the telescoping conveyor sections is lowered, and the sections are moved into the body of the truck. Feed of cartons into the truck is controlled by a pushbutton mounted on the leading telescoping section. As the front end of the truck is loaded, the conveyor sections can be gradually retracted so that the truck loader has ready access to cartons at all times.



DRILLING AND PINNING GEAR UNITS

By **R. G. JUSTIS,** Production Engineer, Electronics Div., Westinghouse Electric Corp., Baltimore, Md.

PRECISION gearing units are needed in electronic equipment to aid in the adjustment of coils, variable capacitors, and other electrical components. In planning for the assembly of these units on a production basis, numerous opportunities can be found in manufacturing processes where gears may be pinned to shafts before the components are finally assembled into electronic equipment. By preassembling these units in quantity, time is saved in the assembly of both the gearing units and the electronic equipment. Such assembly also provides an opportunity to accomplish the job on automatic equipment that can be specially designed to do the task efficiently.

With this in mind, the semiautomatic, air-operated assembly machine shown in *Fig.* 1 was developed by Westinghouse Electric Corp. The machine consists of a four-station, pneumatically indexed table which rotates fixtured parts to a drilling station where a gear hub and a shaft are drilled as a unit and then to a pinning station where a steel spring pin is pressed into the drilled hole. With the exception of the table fixtures and the pin feeding device, most of the components comprising the machine are standard, off-the-shelf units which required little or no change for use in this installation.

Operation of the machine is relatively simple. An operator unloads a completed gearing unit and then loads a shaft and gear into a fixture. After tightening a thumbscrew on the fixture, the operator presses an air valve pushbutton to start the automatic machine cycle which is controlled by a cam-type electropneumatic timer. The air valve pushbutton actuates a pneumatic valve and causes a small air cylinder to depress an arm on the electropneumatic timer and engage a connecting gear between the reduction

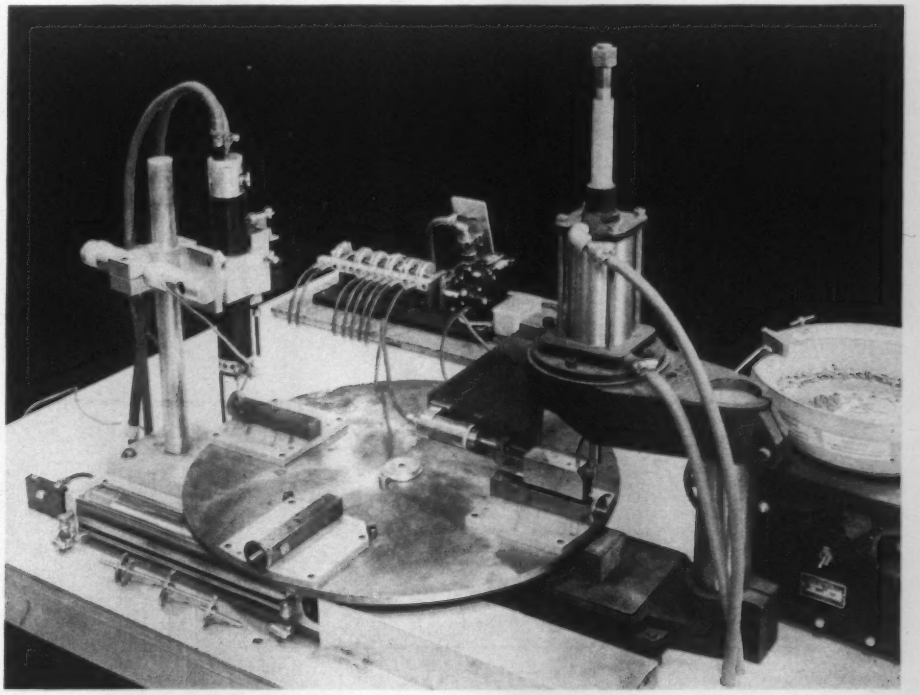


Fig. 1—Semiautomatic drilling and pinning machine was developed to drill a gear hub and a shaft simultaneously and then to insert and press home a steel spring pin. Air-operated drill is on the left of the pneumatically indexed table, and the inserting ram is on the right of the table. Behind the ram is a vibratory feeder which feeds pins to the inserting ram feeder. In the center background is an electropneumatic timer which controls all pneumatic operations of the machine. Several types of gearing units assembled on the machine are in the left foreground.

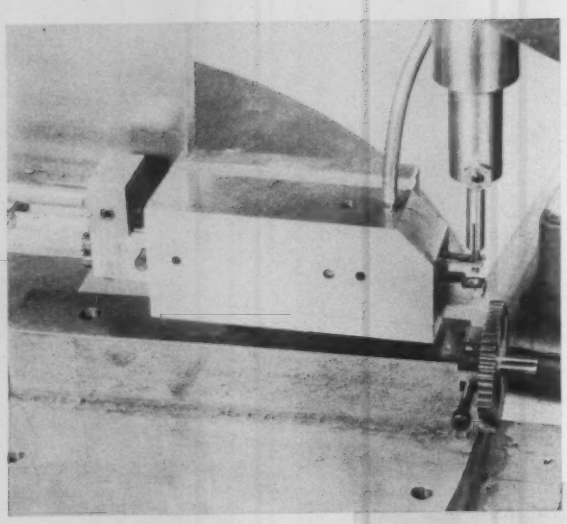


Fig. 2—Inserting ram feeder was developed by Westinghouse engineers to automatically feed spring pins to the inserting ram. At this point in the operation, the lift shoe has pressed a pin into the inserting ram collet and is beginning to retract to home position. The guide plate above the lift shoe has a split hole so that pin will slip out when plate retracts.

gear motor drive of the timer and the sequence timing cams of the unit. Also actuated at this time is an air-mist coolant system which lubricates the drill of the air-operated drilling unit.

The cam-operated electropneumatic timer is a standard unit manufactured by Mead Specialties Co. It has six cam units which can be used to operate either twelve single-acting air cylinders or six double-acting cylinders. Trip levers can be positioned at any position around the circumference of each cam to actuate bleeder valves from either side of a cam. The bleeder valves are connected to four-way valves which do not have a neutral position. When a cam trip lever actuates a bleeder valve, air is exhausted from one side of a pilot piston in the four-way valve, causing the piston to shift to that side of the

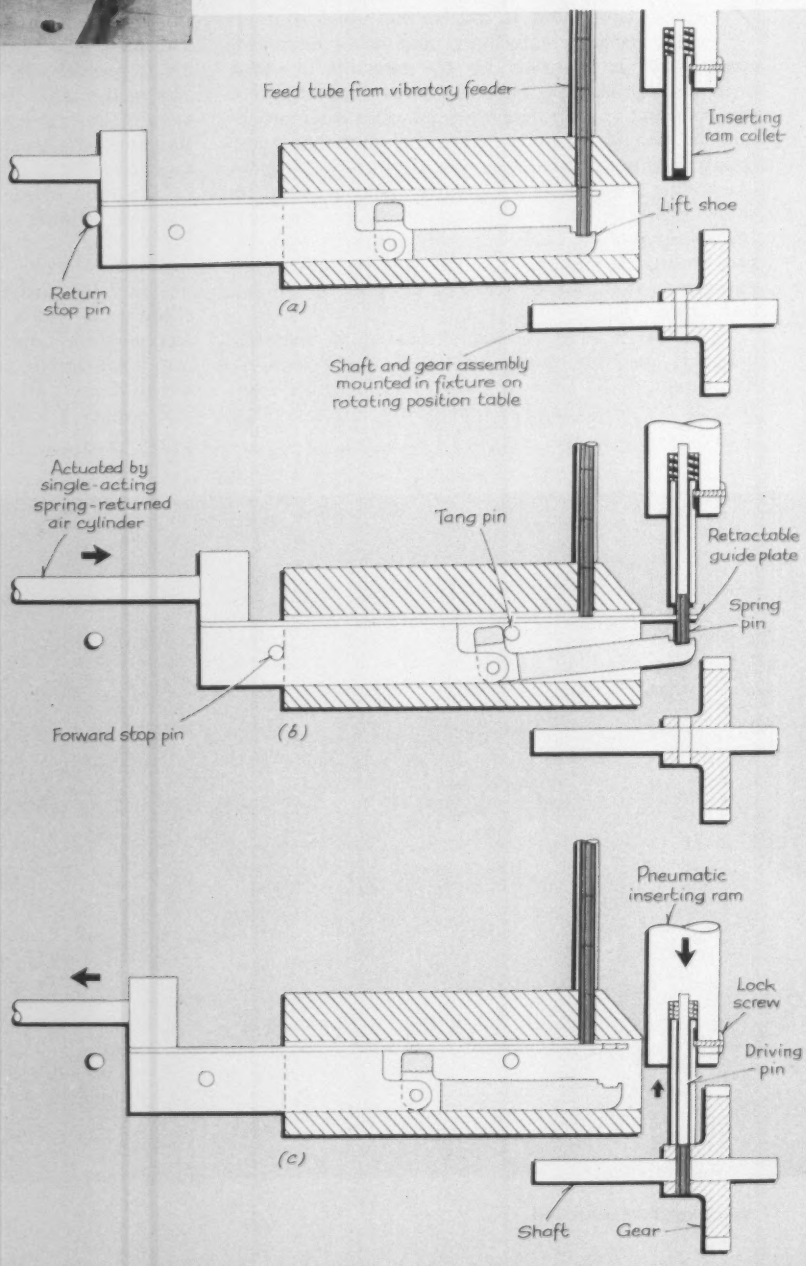


Fig. 3 — Diagram illustrates the operation of the inserting ram feeder. Feed tube from vibratory feeder aligns pins. When guide plate is in home position *(a)*, a pin drops through split hole in the plate and comes to rest in guide hole of lift shoe. Electropneumatic timer cam actuates air cylinder, causing guide plate and lift shoe to move pin toward inserting ram collet. Tang on lift shoe strikes against tang pin, causing the lift shoe to raise and press the pin into collet *(b)*. Retraction of air cylinder moves guide plate and lift shoe back to home position, and timer cam actuates inserting ram cylinder *(c)*. Inserting ram presses pin into gear hub and shaft until collet hits hub. Collet then stops while the driving pin presses pin into hole and flush with gear hub.

valve and to open one port of the main valve while closing the other port. When the bleeder valve connected to the other side of the pilot piston is tripped, the piston moves to the other end of the valve, reversing the ports in the main valve.

When the operator has loaded a fixture and actuated the electropneumatic timer, previously loaded parts have been already drilled and pinned in their respective stations. As the timer cam shaft rotates, a trip lever on one cam actuates a bleeder valve which causes a four-way valve to shift and admit air to the blind end of the table indexing cylinder. Although the rod of this cylinder extends, the table is not indexed at this time. This four-way valve also admits air to a single-acting, spring-returned cylinder at the pinning station which transfers a steel spring pin into the collet of the pneumatic pin inserting ram.

As the timer cam shaft continues to rotate, a trip lever on a second cam actuates a bleeder valve which reverses the valve controlling the table indexing cylinder, admitting air to the rod end of the cylinder and causing the rod to retract. This action indexes the table 90 degrees. At the same time, air is shut off from the pin feeding cylinder, causing the mechanism to retract into home position to pick up another pin.

The previously loaded gearing unit is now in position to be drilled. Since the air-driven drill runs continuously while the machine is in operation, cam control is required only to actuate the feed and withdrawal cycle of the drill. This cycling is accomplished by a third cam which has five trip levers attached to it. Three of the trip levers actuate a bleeder valve which causes a four-way valve to shift and admit air to the drill feed mechanism. Two of the trip levers actuate a second bleeder valve to cause the withdrawal of the drill after each penetration. Therefore, the drill is advanced three times and retracted two times on a timed basis for each drilling cycle in order to clean chips from the drill flutes. When the drill has reached its proper depth, it actuates a limit valve mounted on the side of the drill motor. This valve allows the drill to retract for the third time. A trip lever on the side of a fourth cam causes the limit valve to reset for the next drilling cycle.

At the conclusion of the drilling cycle, a trip lever on the fourth cam actuates a bleeder valve which causes a four-way valve to shift and release air being supplied to the gear-engaging cylinder of the electropneumatic timer. This action disengages the connecting gear between the timer drive and the cam shaft.

The next time the operator loads a fixture and initiates the automatic machine cycle, the gearing unit just drilled is indexed by the table to an idle station opposite the load-unload station. At this station, a tube connected to a valve exhaust port is used to blow any remaining chips from the drilled hole. When the table is indexed for the third time, the gearing unit is moved into the pinning station, *Fig.* 2.

The spring pins are contained in a Syntron Co. vibrating feeder which aligns them longitudinally and feeds them through a tube to the inserting ram feeder. During the automatic machine cycle, a trip lever on the first cam of the timer causes the rod of the inserting ram feeder cylinder to advance and position a pin into the collet of the inserting ram. During the drilling cycle at a previous station, a trip lever on the fifth cam of the electropneumatic timer trips a bleeder valve which causes the inserting ram cylinder to actuate through a four-way valve. The ram then presses the pin into the gear hub and shaft as shown in the diagram in *Fig.* 3. At the conclusion of the pressing operation, another trip lever on the fifth cam causes the inserting ram to retract to its home position.

The rotary indexing table, inserting ram, electropneumatic timer, small air cylinders, and valves were obtained from Mead Specialties Co. The air-operated drill unit was furnished by Aro Equipment Corp. Many different types of gear and shaft units can be drilled and pinned on this machine, and some of these are shown in the left foreground of *Fig.* 1. In addition, various other types of assemblies can be produced by the machine by changing the four holding fixtures. These include such assemblies as hinged units and parts used as linkages.

pneumatic conveying system handles coarse starch

INSTALLATION of a high density pneumatic conveying system at American Maize-Products Co. has reduced both operating and maintenance costs in the handling of coarse starch. Prior to the installation of the pneumatic system, a split rubber tubular belt conveyor was used to transport 7500 pounds of starch per hour. Density of the starch is 31 pounds per cubic foot.

The belt conveyor had a life expectancy of approximately three years and a replacement cost of approximately $15,000. At times, it was affected by temperature changes which caused it to occasionally jump its track. In addition to temporarily halting production, considerable maintenance effort was required to get the system back in operation after a breakdown caused by the conveyor jumping its track.

The belt conveyor system was replaced by a Sprout, Waldron & Co. Inc. positive pressure high density pneumatic conveying system. The system has the same capacity as the belt conveyor and is designed to be 99.5 per cent efficient, with dust loss from the collector discharge not to exceed 30 grains of starch per cubic foot of air. During transport, the starch is lifted 70 feet and carried over a horizontal run of 340 feet.

The pneumatic conveying system has been operating satisfactorily on a twenty-four hour, five-day week schedule. According to officials at American Maize-Products, it is providing reliable low-cost conveying with a minimum of product degradation.

KEY CODES CONTROL PARCEL SORTING

Improvements in parcel sorting are one of the areas being investigated by the U. S. Post Office Department in a program aimed at keeping pace with staggering increases in mail volume predicted for the future. The semiautomatic parcel sorting system described in this article is undergoing operational tests at several Post Office locations.

REALIZATION on the part of the U. S. Post Office Department that manual methods of handling and sorting mail in post offices will soon be inadequate has resulted in the initiation of several development projects aimed at mechanizing these functions. Magnitude of the problem can be appreciated when historical records and forecasts of mail volumes are consulted. For example, in 1939, U. S. post offices processed 30 billion pieces of mail. By 1958 this volume had increased to 61 billion pieces, and predictions indicate a rise to 122 billion pieces of mail by 1983.

One of the remedies being investigated is the use of parcel sorting machines whereby large quantities of incoming parcels can be rapidly scanned, classified by primary destinations, and automatically routed to

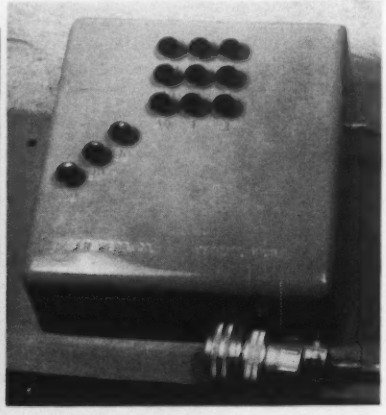


Fig. 1—Two operators are assigned to each dispatching station of a parcel sorting system installed in the Washington, D.C. Post Office. First operator removes parcels from a slide and feeds them to second operator with their addresses faced properly. Second operator reads the address of each parcel, keys its destination in a two-digit code on a keyboard, and places the parcel on a tray moving past the station. Inset shows arrangement of keys on station keyboard.

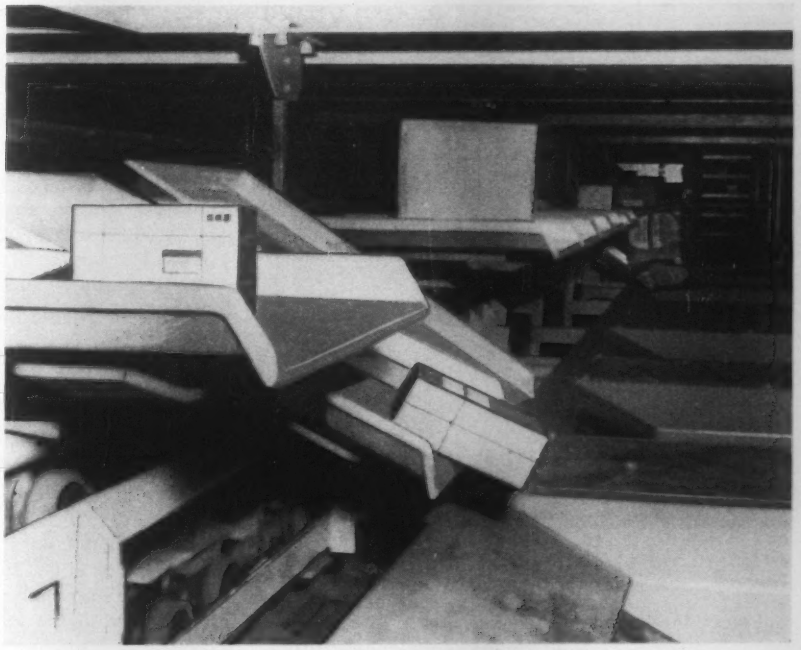


Fig. 2 — After they are loaded, the parcel trays move in a line past multiple discharge points. When a tray reaches the proper discharge point, it is tipped automatically and releases its parcel to a chute leading to a collecting belt. Each collecting belt accumulates parcels for a given destination. The trays are then returned to the dispatching station for reloading.

proper secondary areas for shipment. Such a system, designed and built by Jervis B. Webb Co., is in operation at the Washington, D. C., Post Office.

System Operation and Control

In operation of the system, incoming parcels are distributed from a conveyor belt to six dispatching stations by a constantly reciprocating "plow" above the moving belt. Parcels conveyed to the plow are diverted in approximately equal quantities to multiple, inclined slides leading to the stations.

Two operators are assigned to each dispatching station, *Fig.* 1. The first operator positions the parcels on a table so that the addresses may be easily read by the second operator, or dispatcher. The dispatcher then reads the address on each parcel presented to him and transfers this information to a keyboard in the form of a two-digit code. At the same time, he places the parcel on a tray moving past the dispatching station.

Each parcel tray is pivotally mounted on a wheeled truck so that it can be tilted with respect to the truck. For each machine, a series of trucks is connected by a chain to form an endless loop. Thus, each tray can be moved continuously from the dispatching station where it receives a parcel, past a row of discharge points, and back to the station. As each parcel on a tray reaches the proper discharge point, *Fig.* 2, the tray is tilted automatically to drop the parcel onto a collecting belt leading to a shipping area. Corresponding discharge points for all six tray lines are served by a common collecting belt, so that parcels for a given destination can be collected from any tray line. At the present time, there are 32 collecting belts, representing 31 parcel destinations and a collecting point for errors. An operator stationed at the end of each collecting belt distributes the parcels to sack racks for shipment.

When the dispatcher for a tray line codes the destination of a parcel on the keyboard, an automatic control system, *Fig.* 3, is actuated. Major elements of the control system for each tray line include a short-memory circuit, a synchronizing switch, a magnetic memory drum, and output devices for tripping the trays at the proper discharge points. The synchronizing switch and memory drum are driven in synchronization with the tray line by a direct, mechanical connection.

Electrical code signals from the keyboard are first fed to the short-memory circuit, which retains the signals to allow time for the dispatcher to place the parcel on a tray after coding its destination. The information is released from the short-memory circuit when the synchronizing switch closes momentarily, signifying that the tray containing the parcel has moved to a reference, or starting point.

Signals from the short-memory circuit are then admitted to the proper write heads in the memory drum. The drum contains twelve magnetic discs equipped with write heads, read heads, and erase heads. Each disc corresponds to a possible digit in the two-digit code. Thus, when a two-digit code is entered from the write heads, it is recorded on the discs.

As the tray containing the parcel moves toward its discharge point, the drum is rotated in synchronism such that $\frac{1}{8}$-inch of motion on the periphery of the drum corresponds to 1-foot of tray travel. When the tray reaches the discharge point, read heads on the energized discs sense the coded signals

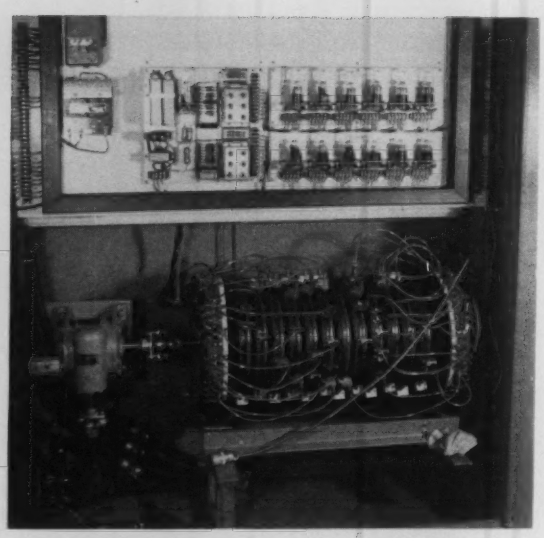


Fig. 3—Control cabinet for each tray line includes a magnetic memory drum, lower right, and a synchronizing switch, lower left. The drum and switch are rotated in synchronism with the motion of the tray line so that code signals entered in the memory drum from the dispatcher's keyboard will be read out when the trays reach their proper discharge points. These signals actuate solenoids to tip the trays at the proper locations.

and actuate a magnetic switch and solenoid. The solenoid then retracts for a preset time, permitting a cam to tilt the tray and discharge the parcel at the proper point.

Only trays for which the proper code has been entered at the dispatching station will be tripped at a given discharge point. When the trays have passed the last discharge point in the line, erase heads on the memory drum clear the discs of signals.

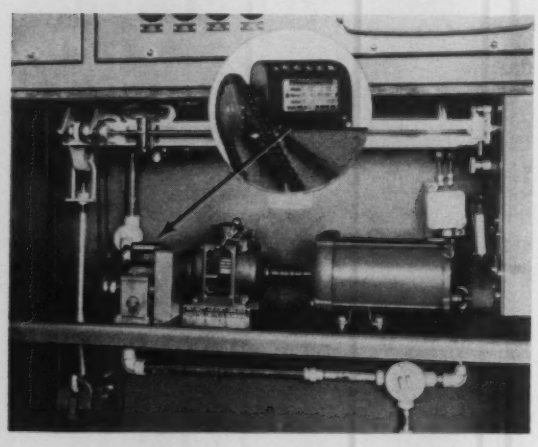
▶ Other Developments

Since each tray line can be operated much faster than one dispatcher can operate the keyboard and load parcels, the Post Office Department is considering assigning two men to key for one machine. Under the plan, two dispatchers would be posted on opposite sides of each tray line and load parcels on alternate trays.

Similar installations are in operation in Post Offices in other cities. For example, six parcel sorting machines are operating side-by-side in Denver, Colo., and two are in use in Flint, Mich. At the latter location, a new design of memory drum is being used. This drum is smaller than the one described, and operates on electromechanical principles. In operation, a signal from the keyboard causes a flag on one of several revolving wheels to change position. As the wheels rotate on a common shaft, the flag which is out of position breaks a beam and actuates a tray-tipping cycle.

feeder dispenses solids at controlled rates

VARIETY of solid materials may be dispensed at controlled rates with a continuous, loss-in-weight type gravimetric feeder developed by Omega Machine Co., Div., B-I-F Industries Inc. The unit continuously feeds and weighs pulverized, granulated, stringy, lumpy, or cohesive solids to an accuracy of 0.5 per cent. Applications for the device are found in the food, chemical, petroleum, fertilizer, and plastics industries.



The unit controls materials flow through a "dead weight" principle in which a hopper containing the material to be fed is mounted on a scale lever system. The hopper and scale lever system are counterbalanced by a scale beam and movable counterpoise.

In operation, the counterpoise is first moved along the scale beam until balance is established. Then, the counterpoise is retracted at a constant rate by a motor-driven lead screw. Speed of the lead screw, and hence rate of retraction of the counterpoise, are related to the desired material feed rate.

A controller, operated from the tip of the scale beam, governs the speed of a feeding mechanism so that material will be transferred out of the hopper at the rate required to keep the scale beam balanced. In this manner, up to 60,000 pounds of material per hour may be transferred from the hopper to a process at a controlled rate.

In selecting a visual readout device for the system, B-I-F chose a rotary counter model manufactured by Durant Mfg. Co. Attributes sought in the counter included a minimum of backlash, good visibility, permanently lubricated bearings, and a corrosion-resistant shaft. The counter is a nonreset type that is connected to the lead screw by a chain and sprocket of the correct ratio to indicate weight in pounds directly. Since each revolution of the lead screw corresponds to a certain weight of material, the counter indicates the exact amount of material that has been fed.

CARD PUNCHING AT DATA SOURCE SHORTENS PROCESSING CYCLE

WITH steadily increasing clerical costs and increases in paperwork, record keeping, and data analyses, industry is confronted with a problem of major proportions in obtaining accurate and timely data for administrative control. Involved are such areas as accepting original orders, updating inventory and stock records, following work-in-progress, collecting data for industrial payrolls, and recording retail sales transactions.

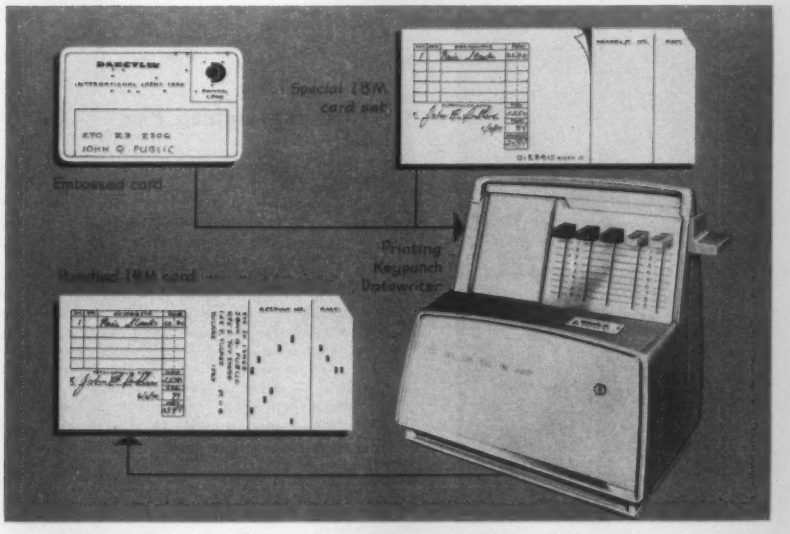
Typically, a large proportion of the work in creating original input data for a modern system is accomplished manually—followed by another manual operation of key punching into a machine or onto a card for subsequent processing. When the original source-document is illegible—which is often—either errors result or time is spent in checking to ascertain what is correct. In short, the data processing link between creation of data and initial machine processing of data is a bottleneck operation so far as efficient data processing is concerned.

Dashew Business Machines Inc., in recognition of the typical occurrence of both fixed and variable data that accompany a transaction, has developed a technique for conveniently recording source data at the point of origin. The technique is built around a combined embossed and punch-coded plastic or metal plate that makes it possible to directly obtain an IBM card without the intermediate manual step of key punching. The technique is closely allied to present techniques involving embossed cards, i.e., as with an embossed credit card which identifies a customer and which is used to print the embossed data on a ticket containing such variable data as date, items, price, sales department, etc.

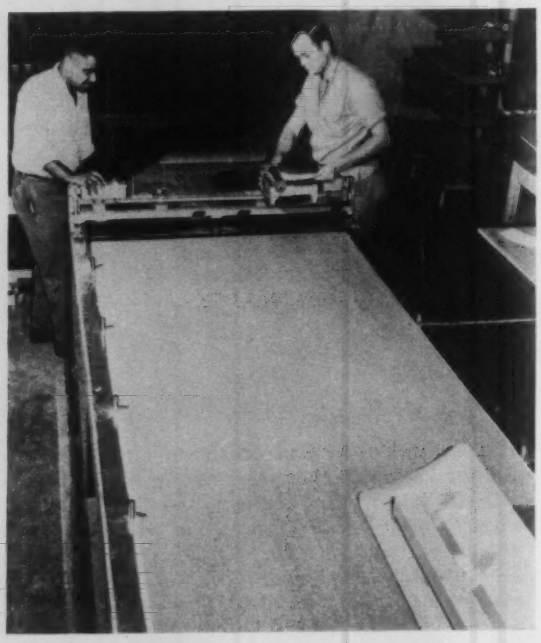
The new system involves an embossed card of familiar size that also includes prepunched holes that act as punching templates. The code holes in the embossed cards are created automatically as part of a standard embossing operation. When the card is placed in a special printing keypunch Datawriter at the source of a transaction, the embossed data can be printed on a special IBM card and the prepunched data transferred to punched holes on the same card. The special IBM card (Port-A-Punch) is prescored to eliminate the need for accurate dies and punches and requires only a printing punch capable of punching out the desired prescored hole.

In addition to the data on the embossed card, the printing keypunch Datawriter can be equipped with a fixed plate which can be locked in the unit in order to print repetitive data, and with preset pins to punch repetitive data. Variable data of up to five numerals can be directly punched into the IBM card by means of the machine's keyboard. A special dater enables the date to be imprinted on the card.

In order to obtain an increased data capacity represented by the prepunched holes in the plastic card, a bi-quinary code form can be used in lieu of the standard IBM card code in which one column of hole positions is used to represent a single number or alphabetical character. The bi-quinary coded information is punched into the IBM card in a special field. At some later time the card is processed through an interpolating unit which translates the bi-quinary coded information into normal punched holes on another portion of the same card, enabling further processing by business machines.

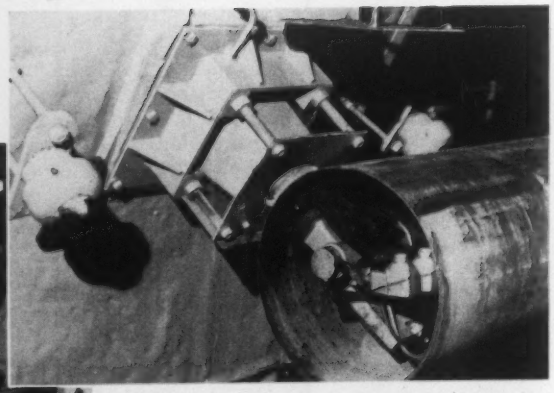


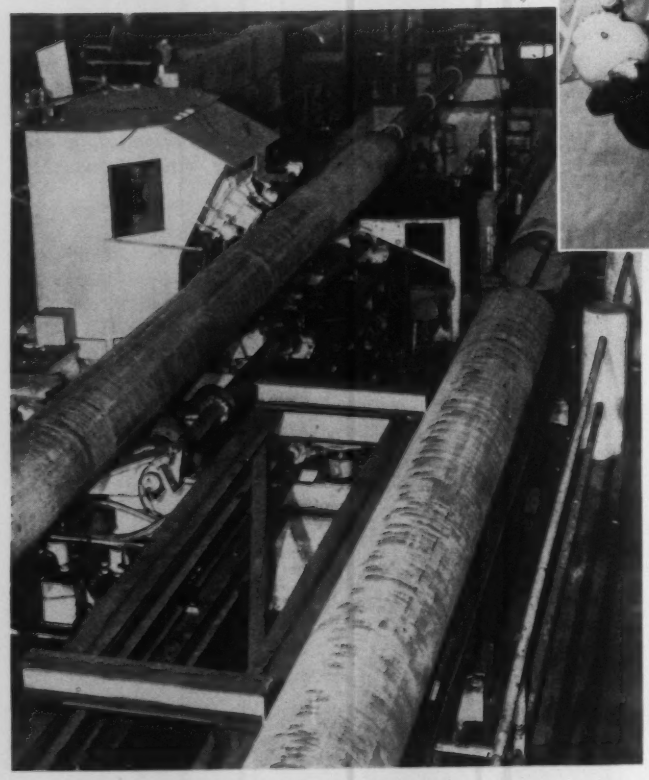
Plastic or metal embossed card is provided with prepunched holes to actuate business card punching unit in Dashew printing keypunch. Additional repetitive data can be printed and punched by preset means. Variable data up to five numerals also can be punched into the IBM cards by a keyboard. The result is an IBM card prepared at the origin of a transaction which can be used in subsequent machine systems without the need of additional keypunch operations. Special IBM card contains prescored holes, and as shown, can be of a multipart form design.



Packaging Laminated Sheets

SHIPPING laminated plastic sheets in 70-pound kraft paper bags has provided Formica Corp. with substantial savings in materials cost, storage and shipping space, and tare weight when compared to the former method of using wood-reinforced boxes. The bagging operation is accomplished on the panel-packer shown which was designed and built by Bemis Bros. Bag Co. Six Formica sheets are interlaced with paper slipsheets, and the bundle is slid onto the loading table in the foreground. An operator secures a paper bag to the packer in the background and presses a button to activate a ram which pushes the bundle into the bag. A second operator attaches a punched card to the package which contains data covering the destination, color, finish, and size of sheets. Carload shipments of the packages are strapped on skids with no additional package protection. Less than carload shipments require paperboard channels and end-caps which are strapped around the perimeters of the packages to protect the sheets from splitting or chipping.





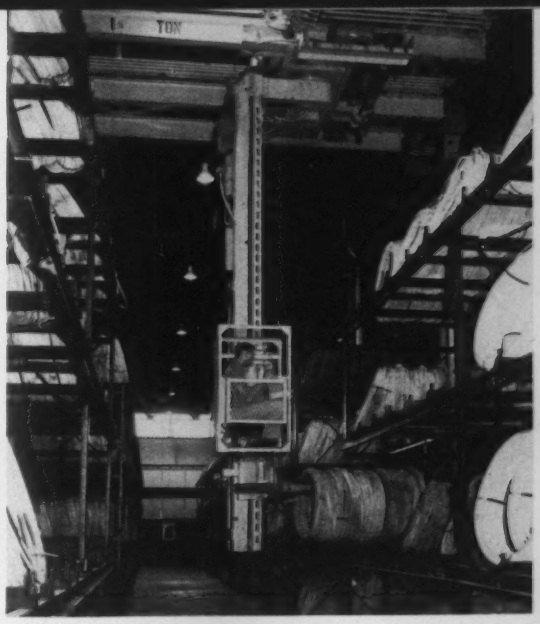
Inspecting Welded Pipe

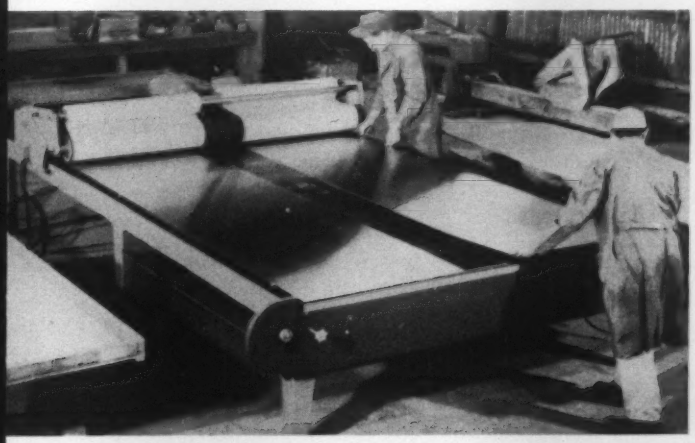
CONTINUOUS fluoroscoping process is being used by the National Tube Div., United States Steel Corp., to detect hidden flaws or defects in welded seams of steel pipe. In operation, 40-foot sections of welded pipe are placed on a carriage which passes in front of an inspection booth at upper left. An x-ray head, mounted on a 48-foot boom, fits inside the pipe in line with the welded seam as shown in the inset. A shadow image of the weld is cast on the fluorescent screen of an image intensifier, and the image is intensified electronically and picked up by a television camera. An inspector inside the booth views the image on a television monitor. If a flaw is detected, the inspector can mark the location by pressing a button which releases a spray of water soluble white paint on the pipe. The inspector can also manipulate controls to position the pipe and control its lateral movement. The system has been in operation at the company's McKeesport, Pa., plant for the past year and a half.

in action

Handling Coils

BY STORING coiled wire stock in racks, Chandler Products Co. is able to accommodate 7500 coils of material, weighing about 1500 tons, in only 20,000 sq ft of floor space. Access to the racks is provided by this man-controlled crane system furnished by the Chicago Tramrail Corp. Two traveling bridges span the rack storage area and a truck dock. Suspended from an overhead trolley, which can transfer from one bridge to the other, is an electrically operated, rotating column which holds the control carriage and ram for handling coils. The operator controls the operations of the bridges, trolley, column, and carriage from his position over the ram. He can load seven coils at the truck dock, maneuver the column up and down aisles, raise or lower the ram to the proper rack, and move the coils into and out of the racks. In addition to conserving floor space, the system has produced an optimum rotation of stock, improved the safety and efficiency of the warehousing operation, and reduced the manpower required to handle the large tonnage of stock.



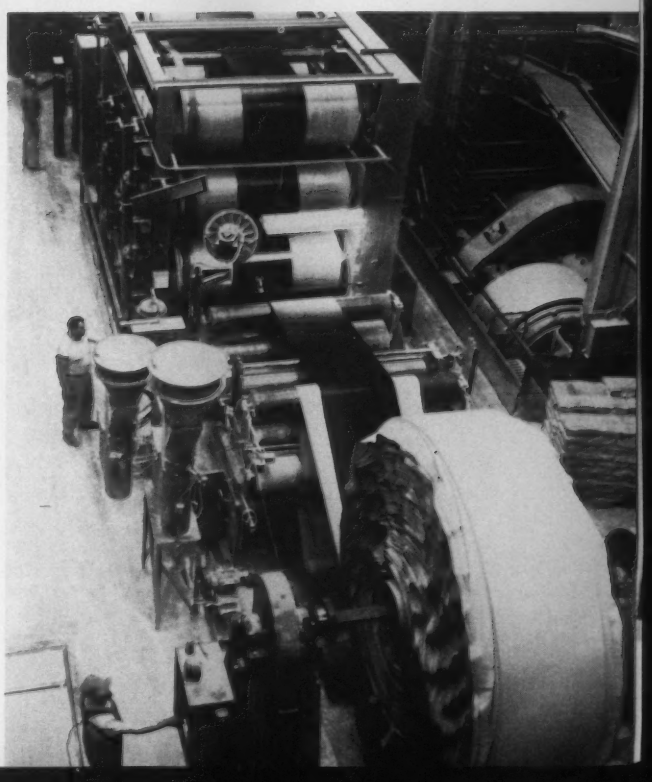


Applying Tape

PROTECTIVE pressure-sensitive tape is applied automatically to large sheets and plates on this taping machine developed by Westoak Machine Corp. In use at Kaiser Aluminum & Chemical Corp., the machine can apply tape to an 84 by 20-inch aluminum sheet at a rate of 50 feet per minute. The tape is applied with no wrinkles or other blemishes, and the machine is equipped with two knife blades to cut the tape to desired length. The machine is powered by a one horsepower motor mounted on an overhead tape supply and carriage unit. Tape for this application was supplied by Minnesota Mining and Mfg. Co.

Calendering Belting

FROM the standpoint of quality and uniformity, calendering operations represent the most critical stage of conveyor belt manufacture. For this reason, the Goodyear Tire & Rubber Co. has installed this new electronically controlled calendering unit, costing $1.6 million, at its Plant II in Akron, Ohio. Only the 12-roll cooling line and coiling unit are shown in this view of the huge two-story system. The unit is designed to handle a maximum belt width of 72 inches and can coil a 13-foot diameter roll having a weight up to 20 tons. To date, the longest continuous piece of belting finished by the unit measured 2200 feet. Uniformity of the product is maintained by x-ray devices which measure the thickness of the material at two points and control the calendering unit.



PARTS LOADER CUTS RIVETING TIME

INCREASED production of paint cans and greater operator safety have resulted from the development of special parts-feeding equipment and tooling for use with a battery of riveting machines. The equipment and tooling, developed by Gear-O-Mation Div., Michigan Tool Co., facilitate the feeding and assembling of bail-holding ears to paint cans. The riveting machines had been equipped previously with automatic feeds for the rivets.

In operation of the parts-feeding equipment, *Fig.* 1, stamped metal ears are placed in a hopper-type bin from which a continuous, impregnated canvas belt rises. The front, upwardly moving portion of the belt is backed by a pair of parallel steel bars. Magnetized Alnico rods act as horizontal spacers for the vertical bars and transfer opposite magnetic polarizations to the bars.

As the belt rises in the bin, ears are attracted in clusters by a strong magnetic field at the bottom of the belt. As they rise on the belt, properly oriented ears pass between guides while improperly oriented ears are wiped off the belt by the guides and fall back into the bin.

Farther up the belt, ears that are not positioned on the belt with their long axes horizontal do not receive the full force of attraction from the parallel steel bars. These parts also fall back into the bin. This process is enhanced by arranging the Alnico rods farther apart in this area so as to weaken the magnetic field.

With these two forms of preselection, the only ears that reach the top of the belt are those that are properly positioned for feeding. As each such part reaches the top, it actuates a mercury switch. This, in turn, activates a cylinder, and the part is transferred from the belt to a feed chute.

Parts entering the feed chute move by gravity to the riveting machine, *Fig.* 2. There, an operator places a can in the machine and operates a foot pedal. This activates a cylinder, causing a feed finger to transfer the leading ear in the feed chute to a position above the can. When the ear is in position, the finger is retracted, and a ram automatically rivets both ends of the ear to the can.

The operator then turns the can 180 degrees so that the first ear falls into a recess in a support saddle beneath the can. The can is thus automatically positioned to receive a second ear opposite the first. The second ear is assembled automatically following another operation of the foot switch. At the end of the riveting cycle, the finished can is removed from the machine. Output of each machine is 700 cans, or 1400 riveted ears, per hour.

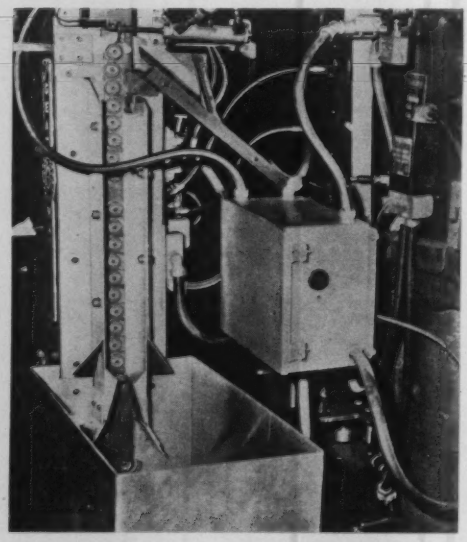


Fig. 1—Parts feeder removes stamped metal ears from a bin, elevates them on a belt, and feeds them to a chute leading to riveting machine at right. Magnetized steel bars behind the belt supply attractive force for holding the parts against the belt. Combination of mechanical guides and controlled magnetic field ensures that only properly oriented parts will reach the top of the belt.

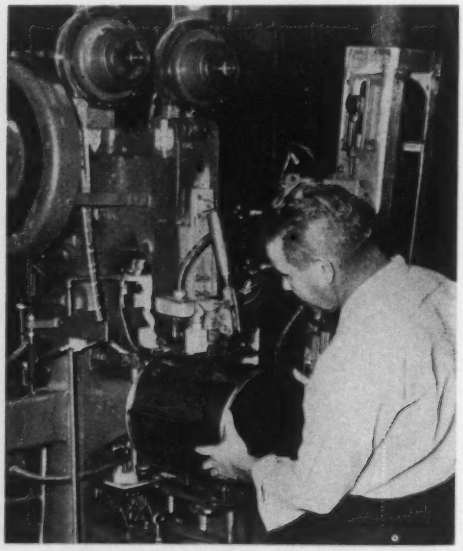


Fig. 2—View of working area of riveter shows manner of loading paint can in machine. Foot switch controls work cycle in which an ear is positioned automatically above the can and riveted in two places. After assembly of first ear, operator rotates can 180 degrees so that ear is held in a recess beneath the can. A second work cycle is then initiated to assemble other ear opposite the first.

Circle 699 on Page 19→

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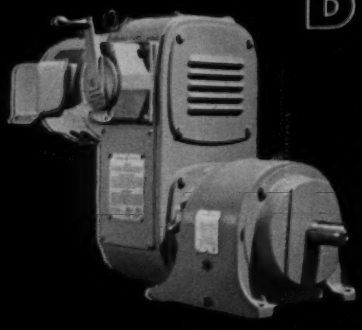

Modern, a-c mechanical drive. ¼–25-hp. Speed range to 10:1. New "Equalizer"‡ provides smooth manual or automatic speed control. Produced by Gear Motor & Transmission Components Dept., Paterson, N. J. Write for Bulletin GEA-6806*.

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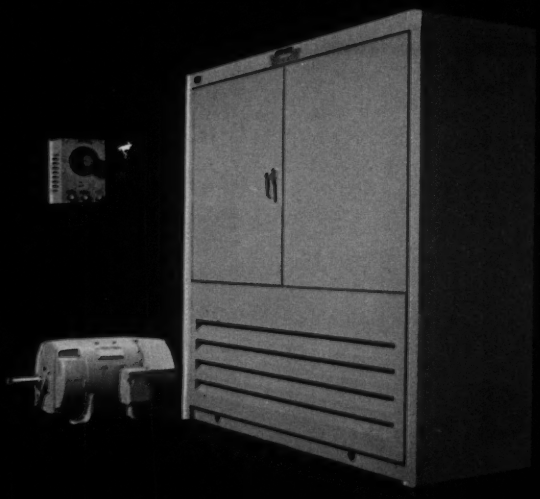

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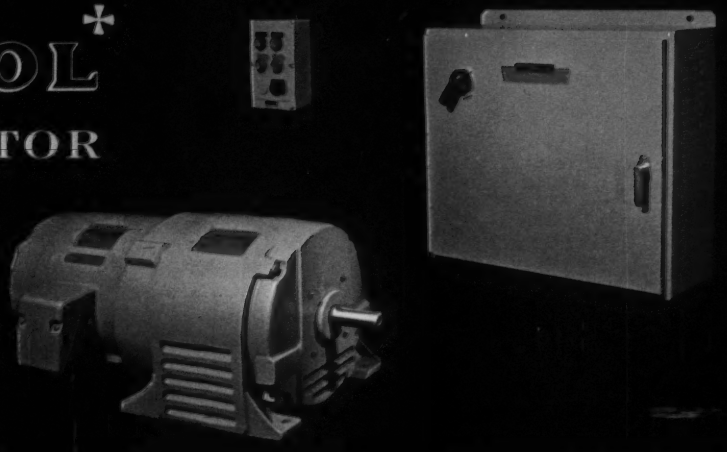

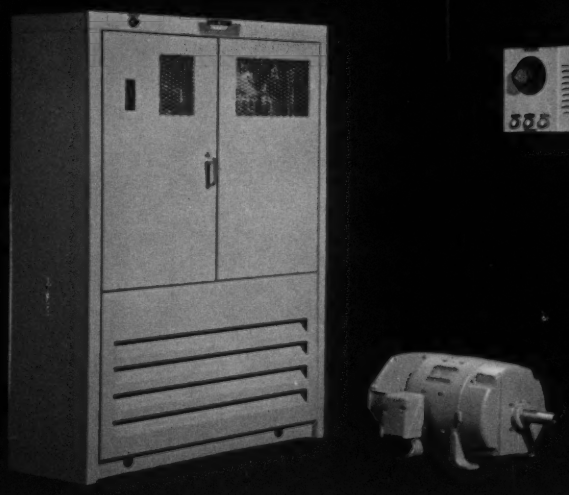

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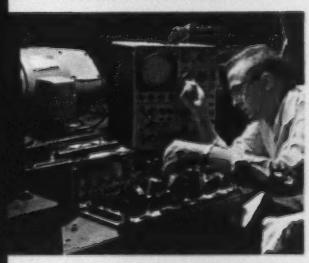

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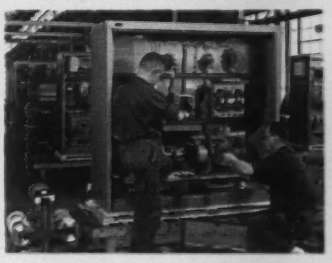

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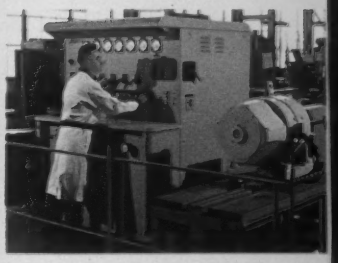

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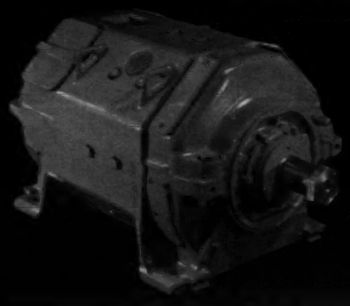

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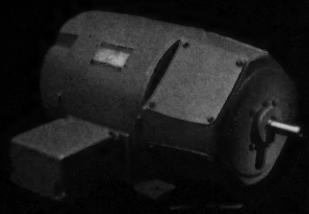

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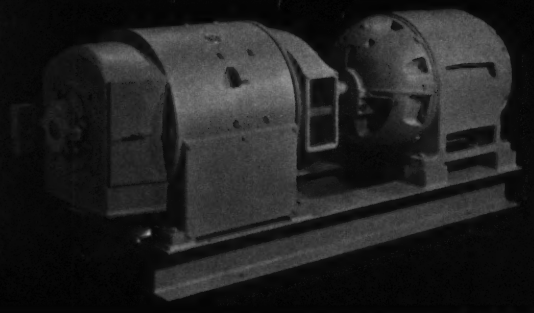

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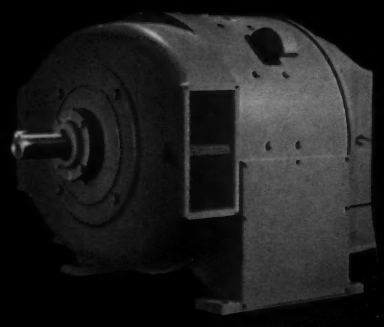

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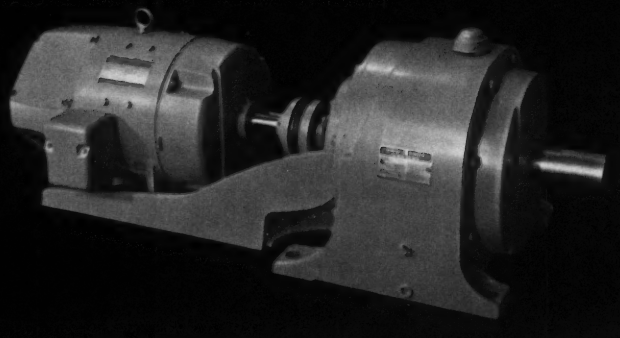
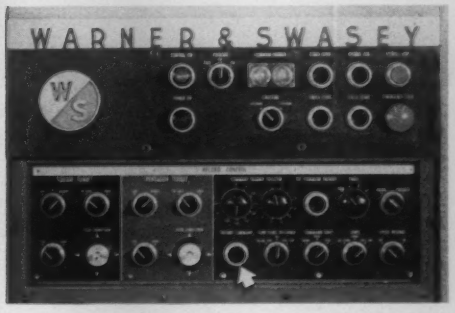


AUTOMATION new equipment

Machines and plant equipment for more automatic operations.
For detailed information and literature, use card Page 19.

Numerically-controlled turret lathe has a 25 inch swing, features an electronic memory system which can store and recall operational commands of any machining setup. An incremental path-control tape system, used for contouring, supplements the lathe's basic memory control. Machine has a square turret mounted on the cross slide and a cross-sliding pentagon turret.

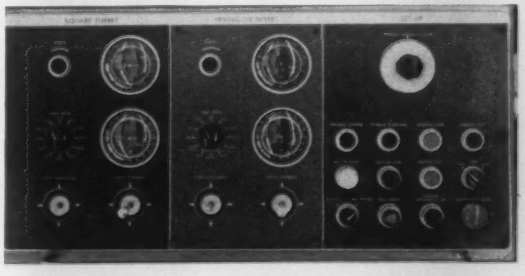


Headstock control panel is used primarily for setup. When a button is pushed, pertinent factors such as the feed, speed, start-of-cut, length, and dimension on the work are assimilated by the memory system in the form of commands. The Record button (see arrow) is used to insert operational commands into the machine's electronic memory system.

Turret Lathe Has Electronic Memory

ELECTRONIC memory system, which is designed to store and recall operational commands of any machining setup, is a feature of numerically controlled turret lathe developed by **Warner & Swasey Co.**, 5701 Carnegie Ave., Cleveland 3, Ohio. The lathe, designated Servofeed, is completely electrically controlled. The built-in memory system can assimilate up to 96 consecutive commands. The commands handle machine functions such as change speed, start rapid, etc. Any command contained in memory can be changed at any time without disturbing other commands. For example, should an alteration be required for a setup, such as a cutter adjustment for tool wear, the operator allows the work to cycle automatically to the cut which needs adjustment. The machine is temporarily switched to hand operation and changes or adjustments to the cutter are made. The *Record* button is pressed and the corrected command is placed in the machine's memory system in the proper sequence. Control can then be returned to the automatic mode, and the machining cycle continued.

Operation of the memory system requires no tape or other outside programming. The operator pushes a button at the end of an acceptable cut during setup. Actuation of the button causes pertinent factors such as the feed, speed, start-of-cut, length, and dimension on the work to be automatically inserted into the machine's memory in the form of commands. An incremental



Control console includes servo-control levers for manual control of square turret and pentagon turret slides. Slide position dials for the square turret cross slide and for the cross sliding pentagon turret show amount of change in position in two directions.

tape path-control system, used for contouring, supplements the lathe's basic memory control. The memory, which is absolute, is used to establish the precise starting point of the contour. When the machining cycle progresses up to that point, the memory unit automatically cuts in tape operation, and the machine proceeds with the contour in correct orientation to other dimensions. Since the memory is absolute, the tape contour can be referred at any time to an absolute position to maintain accurate relationships. The flexibility of the memory system makes it practical to make small corrections for final settings, for tool deflection, or to obtain proper chip action. Corrections can be made in the memory system for a change in a horizontal direction of 0.0005 inch and in a cross direction of 0.00025 inch.

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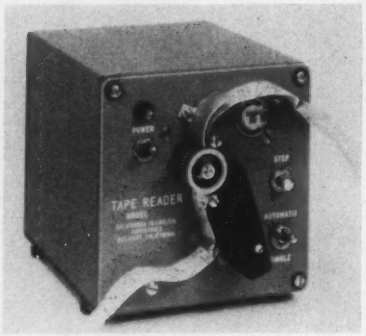

Tape Reader

Single line tape reader is adaptable for use with perforated tape control units. It can operate either single line or continuous run from an external trigger source on the front panel switch. Model 220 can accommodate 5, 6, 7, or 8 hole, one-inch paper Mylar tape. It will operate at a reading speed of 60 lines per second, self-stepping, or 50 lines per second, impulse stepping. Two single line readers working together as a unit can be used with a simple control circuit to create a verifier for punched tapes. **California Technical Industries, Div., Textron Inc.**, 1421 Old County Rd., Belmont, Calif.

Circle 403 on Page 19

Two straight-line units, joined by a storage-conveyor, assemble automobile oil-filter cartridges with four welding and two mechanical joining operations. Production rate is 900 cartridges per hour.

Units Assemble and Weld Oil-Filter Cartridges

Equipment automatically assembles and welds 900 automobile oil-filter cartridges per hour. This includes assembling eight parts with four welding and two mechanical joining operations. Equipment consists of two independently controlled straight-line units joined by a storage-conveyor at an angle between them.

In operation, mounting plates are delivered to the first station of the first unit and positioned one at a time onto the transfer mechanism. In succeeding stations, the pilot of the fitting nut is slipped through the central hole in the mounting plate, and these components are joined by a ring projection weld. After the upper gasket retainer is positioned on the partial assembly, it is projection welded to the mounting plate and is transferred into the storage hopper prior to use in the second machine.

In the second unit, the lower gasket retainer is automatically loaded onto transfer fingers. The subassembly from the previous line feeds onto this retainer and they are projected welded together. Neoprene gaskets are fed from either of two magazines. To insure uninterrupted operation, a sensing unit automatically switches feed from one magazine to the other when the first has been emptied. The gasket is expanded by a circular jaw and, as the partial assembly is elevated beneath it, is stripped off the jaw onto the gasket retainer. Inner filter elements and springs are placed on the assembly manually. Next, outer shells are fed by a magnetic conveyor and loaded one at a time into an upper clamp unit. The partially assembled filter unit is transferred into the station under the shell; the clamp descends; and the shell is slipped over the inner filter element. At the end of this stroke, two spot-welding guns are fired to positively join the shell to the mounting plates. At the last station, the filter unit is clamped between centers and rotating lock-seaming rolls turn the bottom of the outer shell under to provide an oil-tight joint. **United Welders Inc.**, Bay City, Mich.

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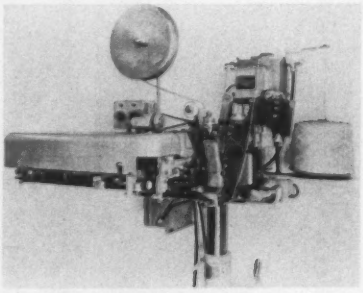
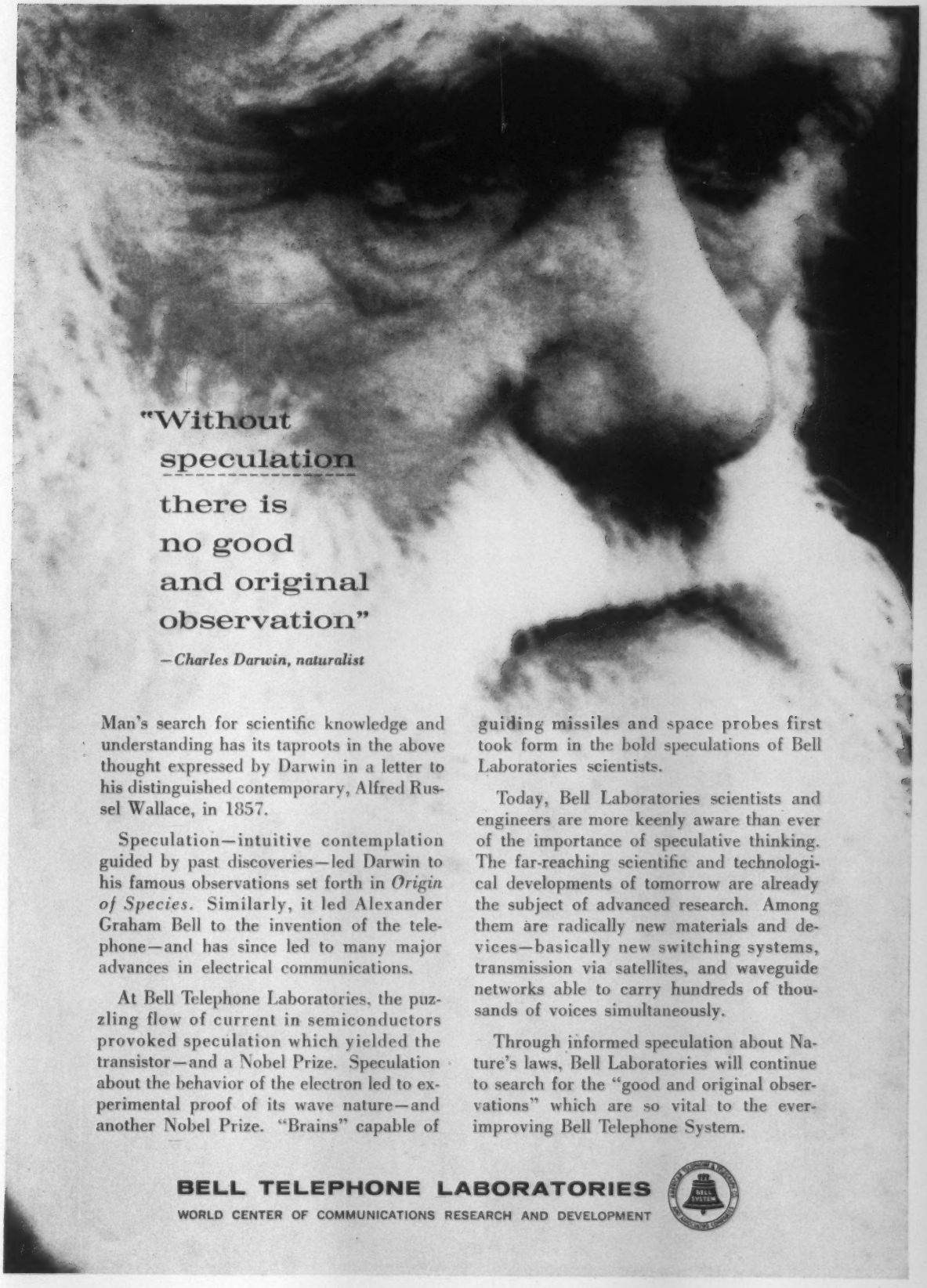


Bag Closing Machine

Equipment applies a thermoplastic tape closure over the sewing on open-mouth multiwall shipping sacks. The closure provides protection against contamination from outside particles, prevents infestation of bags, and creates a moisture barrier to prevent caking of hygroscopic products. A special thermoplastic tape, which provides maximum tensile and tear strength, is used. In operation, the machine



Man's search for scientific knowledge and understanding has its taproots in the above thought expressed by Darwin in a letter to his distinguished contemporary, Alfred Russel Wallace, in 1857.

Speculation—intuitive contemplation guided by past discoveries—led Darwin to his famous observations set forth in *Origin of Species*. Similarly, it led Alexander Graham Bell to the invention of the telephone—and has since led to many major advances in electrical communications.

At Bell Telephone Laboratories, the puzzling flow of current in semiconductors provoked speculation which yielded the transistor—and a Nobel Prize. Speculation about the behavior of the electron led to experimental proof of its wave nature—and another Nobel Prize. "Brains" capable of guiding missiles and space probes first took form in the bold speculations of Bell Laboratories scientists.

Today, Bell Laboratories scientists and engineers are more keenly aware than ever of the importance of speculative thinking. The far-reaching scientific and technological developments of tomorrow are already the subject of advanced research. Among them are radically new materials and devices—basically new switching systems, transmission via satellites, and waveguide networks able to carry hundreds of thousands of voices simultaneously.

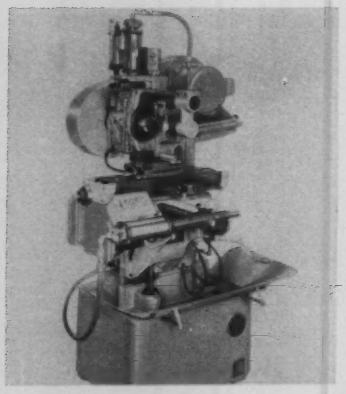
Through informed speculation about Nature's laws, Bell Laboratories will continue to search for the "good and original observations" which are so vital to the ever-improving Bell Telephone System.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

first makes a standard sewn closure. The tape is folded and creased over the stitches, then heat-sealed under controlled temperature and pressure. Once the filled bag enters the sewing guide the rest of the operation is automatic. This includes the starting, thread cutting, tape application, and cutting component functions. **Bemis Packaging Service**, 305 27th Ave. N.E., Minneapolis 18, Minn.

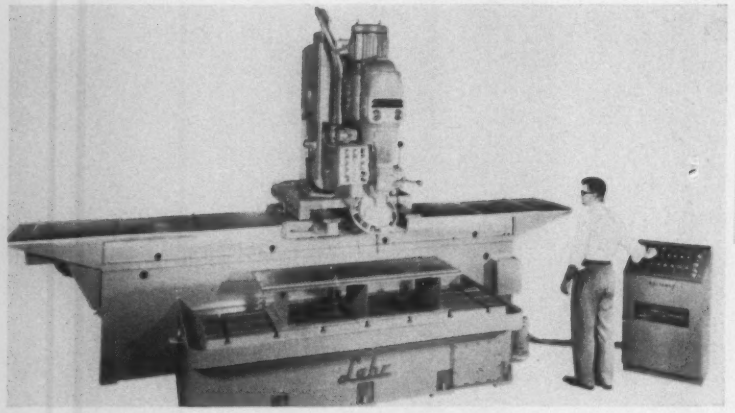
Circle 404 on Page 19



Crystal Slicer

Feature of crystal slicing machine is a variable feed downward plunge-cut with a synchronized automatic increment crossfeed. The downward plunge cut, by means of the automatically-cycled rise and fall spindle head, brings the diamond-charged slicing blade to the work, permitting the crystal boule to be rigidly mounted and supported during the cutting operation. Machine has a mist-lubricated high speed spindle driven by balanced flat belt pulleys and 2 hp reversing motor. Cutter arbors are fitted with special wheel flanges that fling coolant to the periphery of the slicing blade and into the cut. Unit can accommodate slicing blades from 4 inches in diameter or less up to 12 inches in diameter. The automatic increment crossfeed is a pneumatically controlled picker-feed adjustable from 0 to 0.85 inch in steps of 0.001 inch, with a repeat accuracy of ±0.00025 inch per increment. Maximum travel is 6 inches. **National Distributors, REM Sales Inc., Subsidiary, Robert E. Morris Co.**, Box 41, West Hartford 7, Conn.

Circle 405 on Page 19



Programmed Positioning Control

Two-axis, point-to-point numerical control system has been applied to a large drilling machine with a six-face turret head. The machine has a 90-inch long fixed table over which is mounted the turret drilling head which has 90 inches of programmed movement in the longitudinal axis, and 20 inches of programmed movement in the transverse axis.

The numerical input data to the control system can be in the form of 1-inch wide, 8-track punched tape. Decimal readout of the input data is provided by numerical indicator tubes. Full-range zero offset control is provided for both head and saddle motions, allowing the zero datum lines to be set to any position desired. The position-measuring system for both the head and saddle motions is by 3-speed synchro data packages mounted and geared to the machine lead screws. Smallest increment of length and accuracy of both programmed motions is 0.001 and ±0.001 inch. Maximum positioning speed is 150 ipm. A three-axis system has been applied to a vertical drilling machine. **Reliance Electric & Engineering Co.**, 24701 Euclid Ave., Cleveland 17, Ohio.

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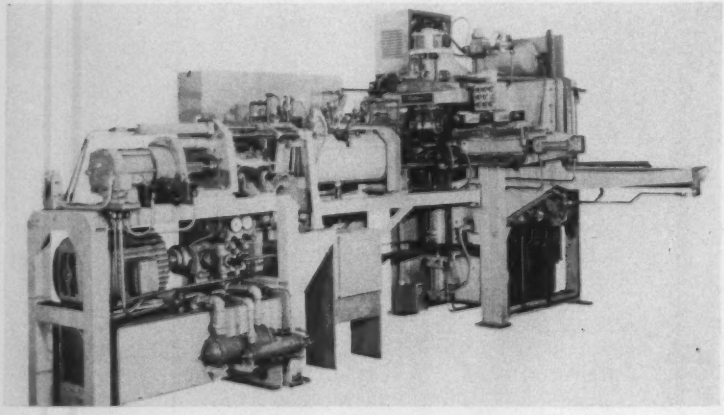
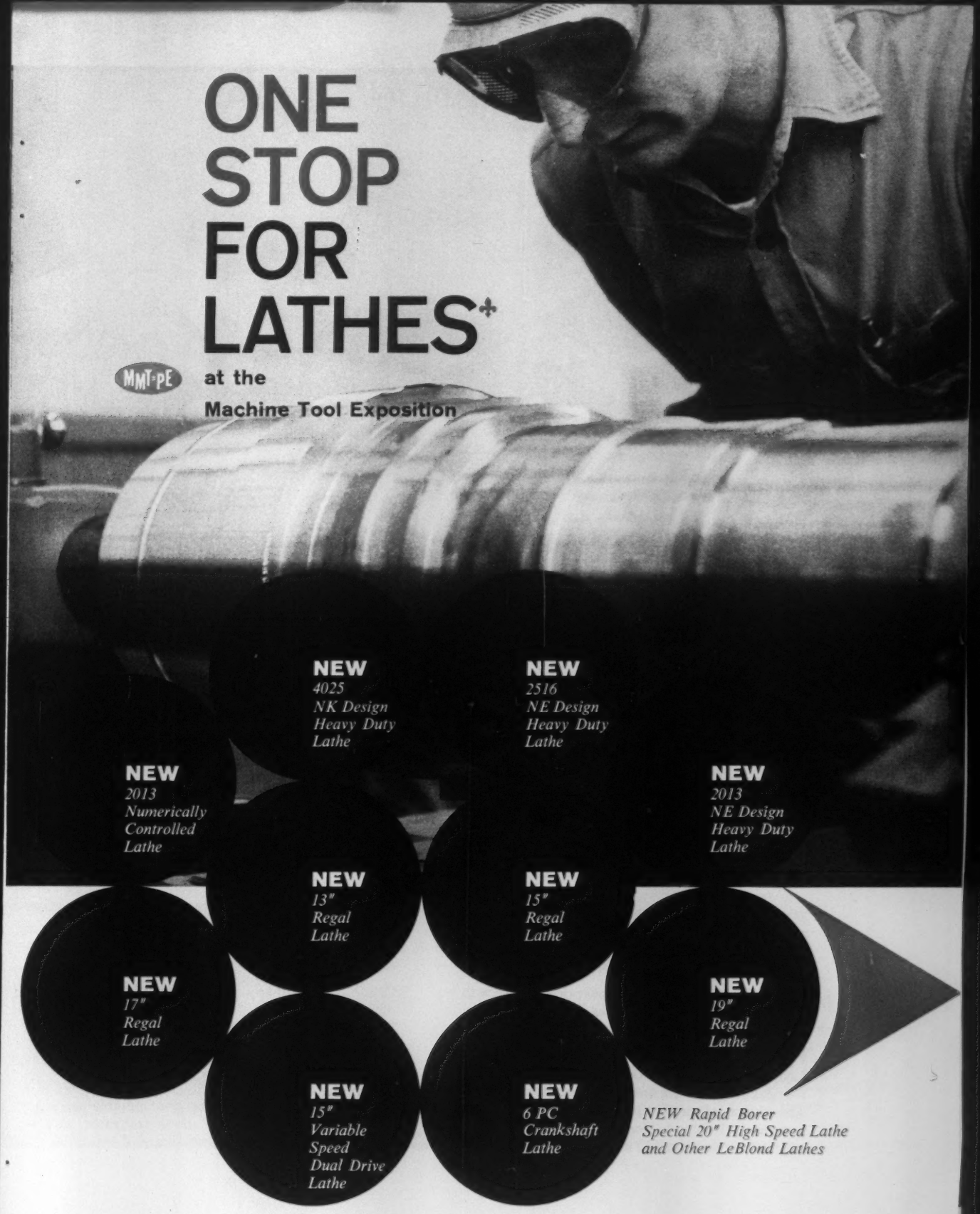


Travelling Head Seam Welder

Equipment has automatic feeding, transfer, and expanding units which produce motor shells from flat sheets at a rate of over 500 shells per hour. In operation, the machine feeds blank sheets from a stock table into the form and weld unit where the sheet is formed into a shell and the overlap edges are seam welded, making a cylinder. The cylinder is then transferred to an expander unit where it is ex-



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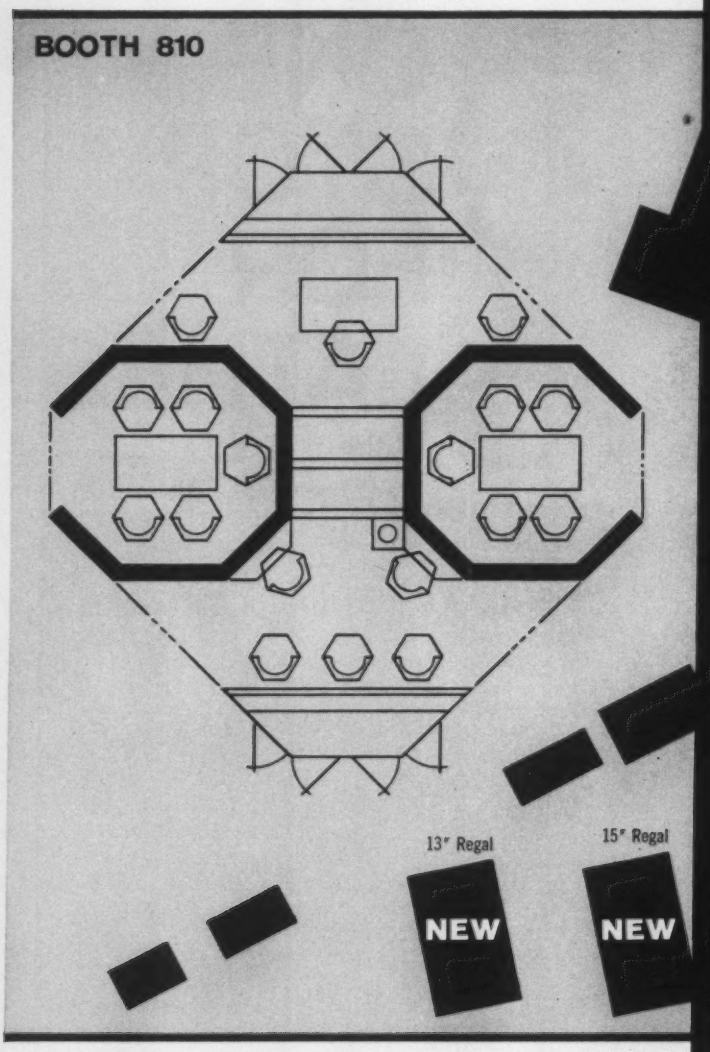


ONE STOP FOR LATHES

at the

Machine Tool Exposition

Wherever you find lathes—in production, maintenance, toolroom and classroom—you will find LeBlonds doing a magnificent job. LeBlond is the world's largest builder of a complete line of lathes.

Choose the REGAL line for low priced lathes with big lathe features. These favorites for light production, maintenance, instrument work, training, and the toolroom are made in 15 different models from 13″ to 24″.

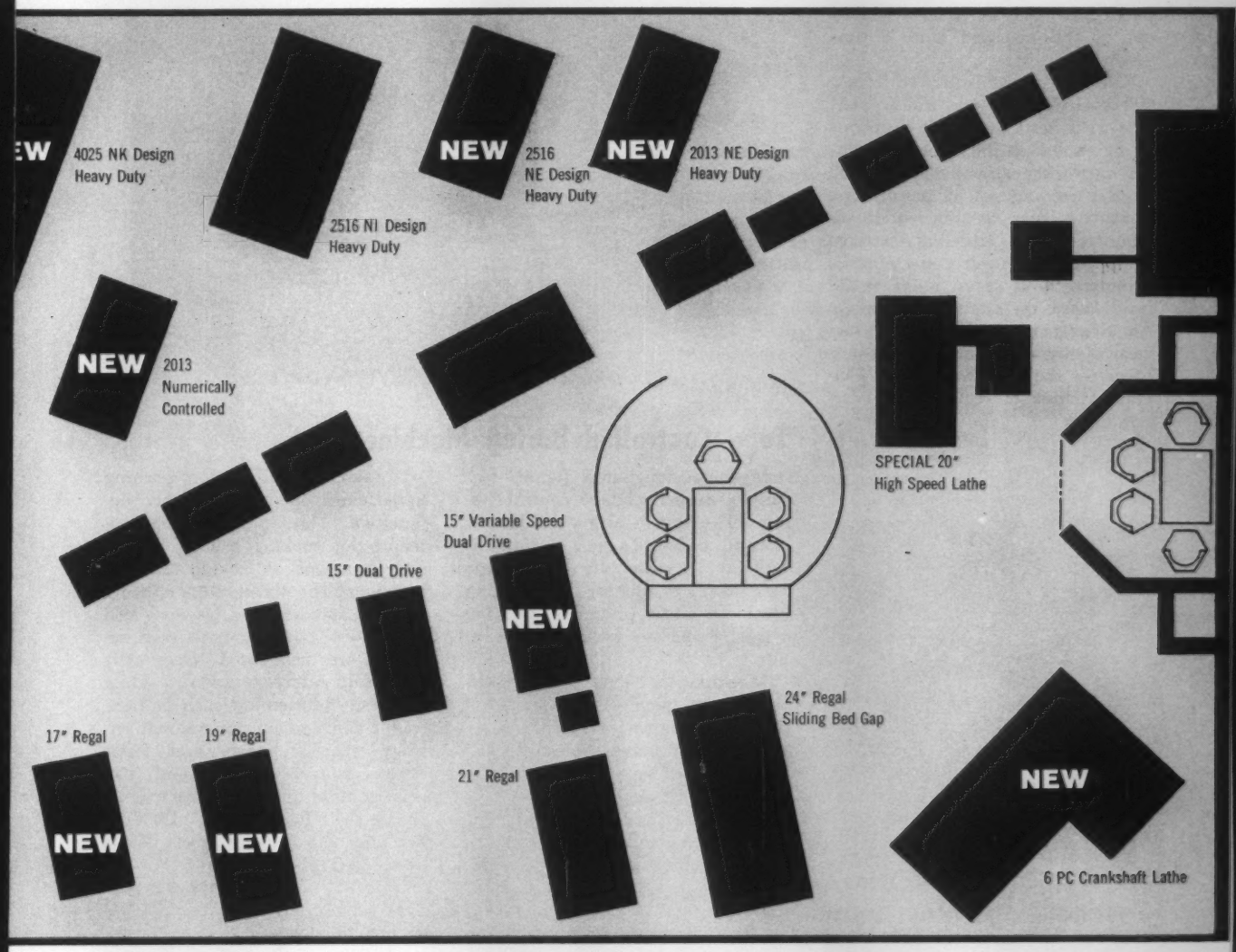
Look to the HEAVY DUTY line for rugged lathes for peak performance and round-the-clock production. The choice of production departments and tooling programs, LeBlond Heavy Duties are made in 6 different series from 13″ to 120″.

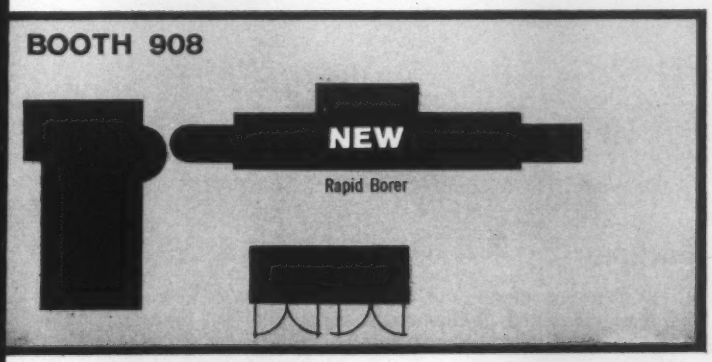
Rely on the RAPID PRODUCTION line for specialized small lathes designed for mass production of specific workpiece categories. Often used with form tooling, they are made in three different models.

LeBlond builds many of these fine lathes in toolroom, plain bed gap, and sliding bed gap models. They may be fitted with a full line of accessories, including *four* different tracers: Regal-Trace, Hydra-Trace, Two-Directional, and 90°, all made by LeBlond.

Sound engineering with ingenuity, three-quarters of a century of experience, a history of notable contributions to better lathe design—these are reason why we say, "With LeBlond, you cut with confidence!"

H 810 • SEE LEBLOND IN BOOTH 908 • SEE LEBLOND IN BOOTH 810 • SEE LEBLOND





Cut with confidence

LeBLOND of Cincinnati

The R. K. LeBlond Machine Tool Company, Cincinnati 8, Ohio

Circle 700 on Page 19

BOOTH 908 • SEE LeBLOND IN BOOTH 810 • SEE LeBLOND IN BOOTH 908 • SEE LeI

panded to size. It is then moved out of the machine onto a conveyor.

The weld power is derived from a 400 kva welding type transformer. The weld head seam unit is operated by an 8-inch diameter air cylinder providing approximately 4000 lb of weld force at 80 psi air line pressure. The welding slide is mounted to a traveling carriage equipped with an air and hydraulic cylinder. Weld speed is 15 to 20 fpm, based on continuous timing. An arrangement is provided so any wear of the weld wheel is distributed across the weld wheel face. **Federal Machine & Welder Co.**, Warren, Ohio.

Circle 407 on Page 19

Testing & Orienting Unit

Equipment tests and orients axial lead resistors, capacitors, and diodes. It is designated for use with company's lead straightening and taping machine, as shown, but it can be used independently. Unit checks and corrects polarity, electronically tests for particular parameter, and either accepts the component or rejects it, if it is not within the specified limits. When the testing and orienting unit is used in conjunction with the lead straightening and taping machine and the feed attachment, it straightens leads, checks and corrects polarity, accepts or rejects, tapes, and packs the components on reels up to 16 inches in diameter, at a speed of 3500 components per hour. **Universal Instruments Corp.**, Dept. AC, 139 E. Frederick St., Binghamton, N. Y.

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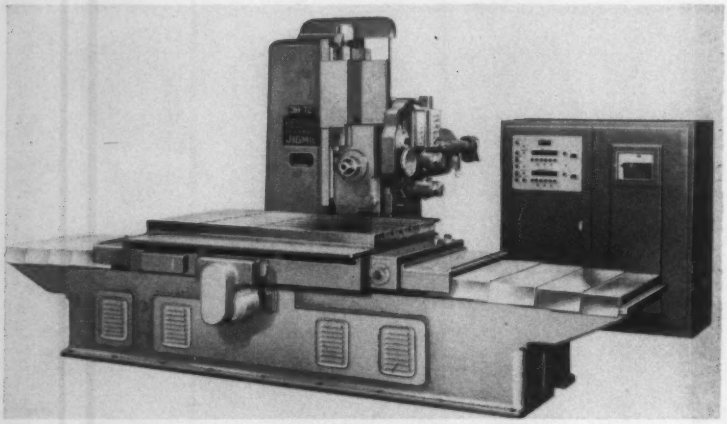

Tape Controlled Boring Machine

Machine designated Jigmil, features a numerical tape control system. The system of automatic tape control, called Tapac, is a point-to-point system for automatic measuring, positioning, and cycling complete parts programs utilizing 1-inch, 8-channel punched tape input.

Machine functions such as the selection of spindle speeds and spindle feeds, control of spindle depth of feed, automatic spindle rapid traverse, feed and retraction, and automatic advance to new hole locations can be programmed into the tape control. Features of the system include: Automatic locking of the slides, tool change warning signal, and operation number designation. The programming procedure for making a tape is that such functions as locking and unlocking of the slides, automatic retraction, spindle rapid traverse, feed and return, and automatic tape advance are sequenced electrically with full safety interlocks. Only the basic information such as horizontal and vertical dimensional settings, spindle speeds and feeds, depth control settings and tool change, need to be programmed into the tape. **Jigmil Div., De Vlieg Machine Co.**, Fair Street, Royal Oak, Mich.

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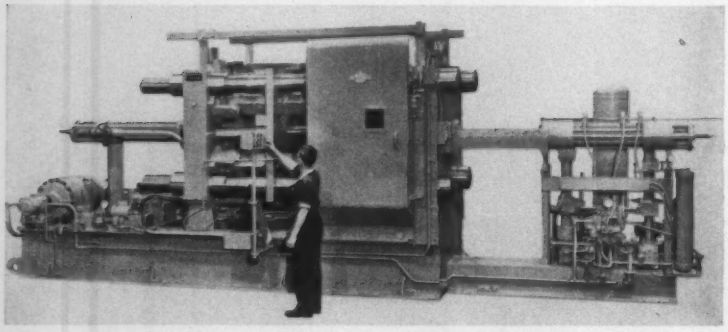


Diecasting Machine

Cold-chamber, high pressure injection type, 1000-ton diecasting machine is designed for aluminum. It checks out at 1200 tons lock-up pressure on the strain-gage test. The platens of the unit are 5 feet high, 5 feet wide, and 1 foot thick. The four tie bars measure 8 inches in diameter. Hydraulic and electrical safety features provide dual control in all areas. **B & T Die Casting Machinery, Div., Greenlee Bros. & Co.**, Rockford, Ill.

Circle 410 on Page 19

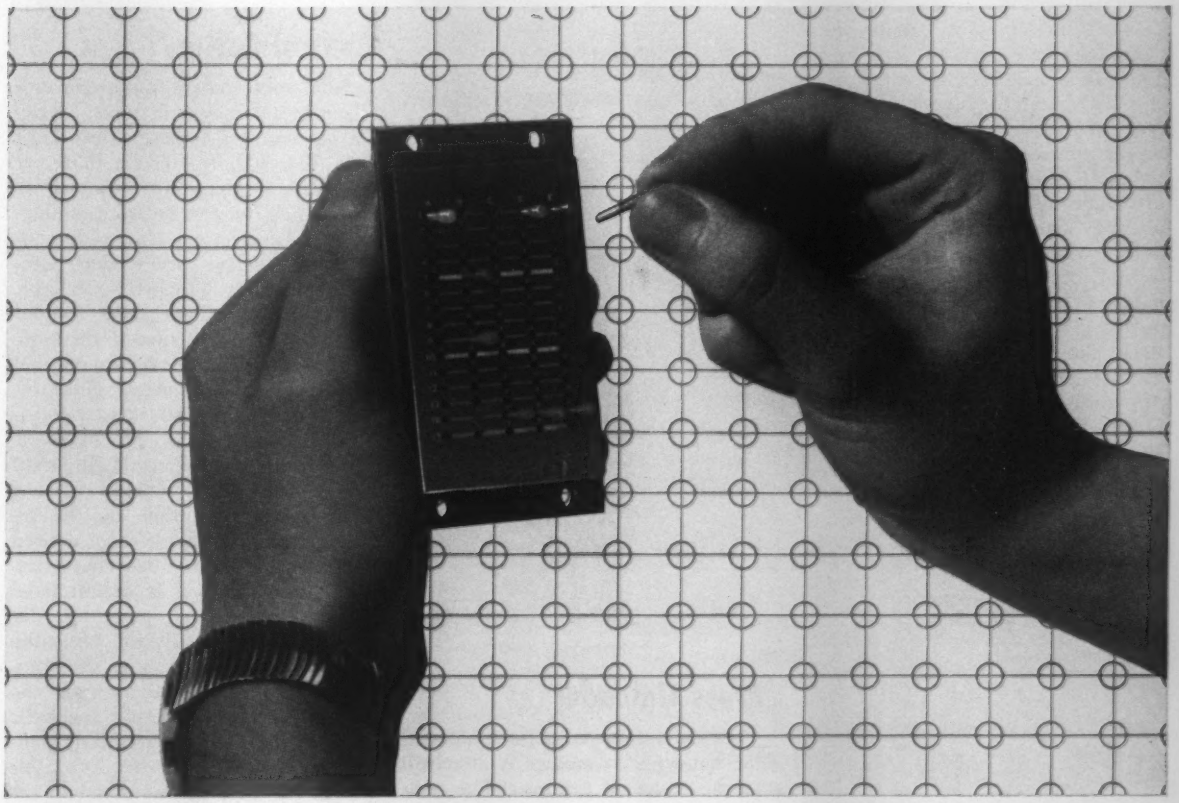
PIN POINT PROGRAMMING

AMP PINBOARDS can do a host of dry circuit switching or commoning functions . . . permit numerous matrixes in one assembly. Complicated switching functions can be accomplished by simply inserting or removing a pin.

You can use these PINBOARDS as modular building blocks for instrumentation applications, automated tooling, test equipment, data processing . . . any variety of size and grid arrangements in multiples of a basic 15 x 5 hole pattern. Contact springs can be bussed in any combination desired. And for safety, there are no exposed conducting surfaces on the rear side of the board. The conducting area of the pin is safely inside board before contact is made with mating springs.

AMP PINBOARDS are factory pre-wired to your specifications . . . with standard or special silk screen legends. Designed for simplicity . . . flexibility . . . reliability . . . with three amperes continuous current rating.

Write for complete specifications.



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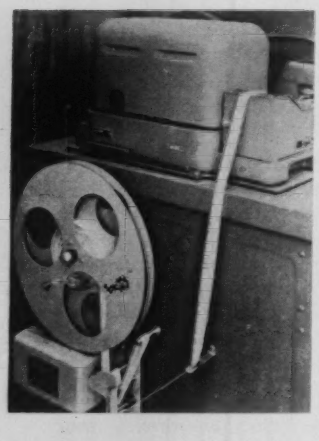
AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

Circle 702 on Page 19



Tape Winder

Unit is designed for use in storing or transmitting tape, in teletypesetting of newspapers and magazines, in integrated data processing, and in automatic letter typing. The tape winder holds up to 1300 ft of chadless and up to 2000 ft of fully perforated tape on a 12-inch reel. The reel is magnetically held to the rotating frame for simple, snap-off removal. The tape is removed by a simple rotation of the two sides of the reel. Reel posts are changeable to handle different widths or levels of tape. Safety feature of the unit is that when the run of tape being wound becomes taut, it opens a mercury switch, cutting off motor power. When the tape becomes slack, the switches closes again to begin winding the tape. **Western Apparatus Co., Div., Comptometer Corp.**, 5600 Jarvis Ave., Chicago 48, Ill.

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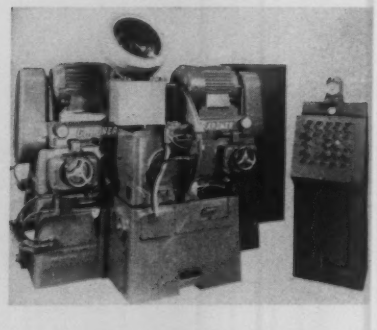

Double Spindle Grinder

Disc grinder with two horizontal spindles grinds bearing roller ends at a rate of 12,000 to 15,000 pieces an hour. Two abrasive discs 23 inches in diameter simultaneously grind opposite ends of the rollers parallel to 0.0001 inch and square with the outside diameter of the roller to 0.0001 inch. Uniformity tolerance is 0.0003 inch, stock removal is 0.006 to 0.008 inch, and finish is 12-15 rms. Automatic dressing cycle begins after a predetermined number of pieces have been ground. The carrier clears automatically. The abrasive discs are retracted and dressed by a swinging-arm, power-operated dresser with precision cluster diamond head. The discs are returned hydraulically to within 0.0001 inch of grind line. At this time, the loading and grinding operations automatically resume.

After grinding, the workpieces move through a machine control trend sizing gage. When the gage shows pieces nearing the high side of tolerance, the automatic increment feed mechanism advances the discs alternately to compensate for abrasive wear. Workpieces are ejected into a wire basket by a coolant jet. **Gardner Machine Co.**, Beloit, Wis.

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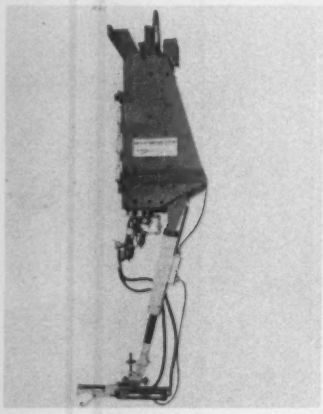

Press Unloader

Swing arm-type press unloader for removing stampings is attached to the crown of a press. The unit is electrically controlled by the press and will operate at speeds up to 40 strokes per minute, with 45 psi air pressure. The swinging arm provides a vertical lift for the stamping, with a non-dipping unloading stroke. Adjustable hardened gibs and long life roller bearings in the self-enclosed frame keep maintenance at a minimum. Several jaw assemblies are available to fit three standard arm models. **Press Automation Systems Inc.**, 25418 Ryan Rd., Warren, Mich.

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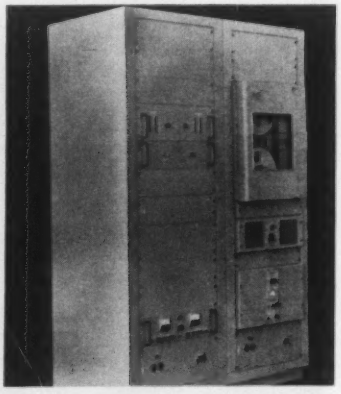

Control Buffer

Solid state control buffer can produce digital magnetic tapes in the format required for entry into IBM 650, 704, 705, or 709 machines, or into other computers. Input to Model ZA-751 can be from analog-to-digital converters, time code generators, punched card readers, electric typewriters, punched paper tape, and digital magnetic tape. Digital input data are presented to the basic format control buffer on six parallel lines. A load command pulse received from the data source transfers the data into the magnetic core memory. Each six-digit group of input data is defined as one character. The buffer can be set to produce records of any desired length from one to 1024 characters. A complete record is accumulated before the digital tape recorder runs. The buffer control starts the digital tape recorder and the complete record is read out of the memory onto the output magnetic tape at the specified recording density of 200 characters per inch. The magnetic core memory continues to accept input data during the time information is being read out onto the magnetic tape. Within limits, the input to the buffer is independent of the output. **Electronic Engineering Co. of Calif.**, 1601 E. Chestnut Ave., Santa Ana, Calif.

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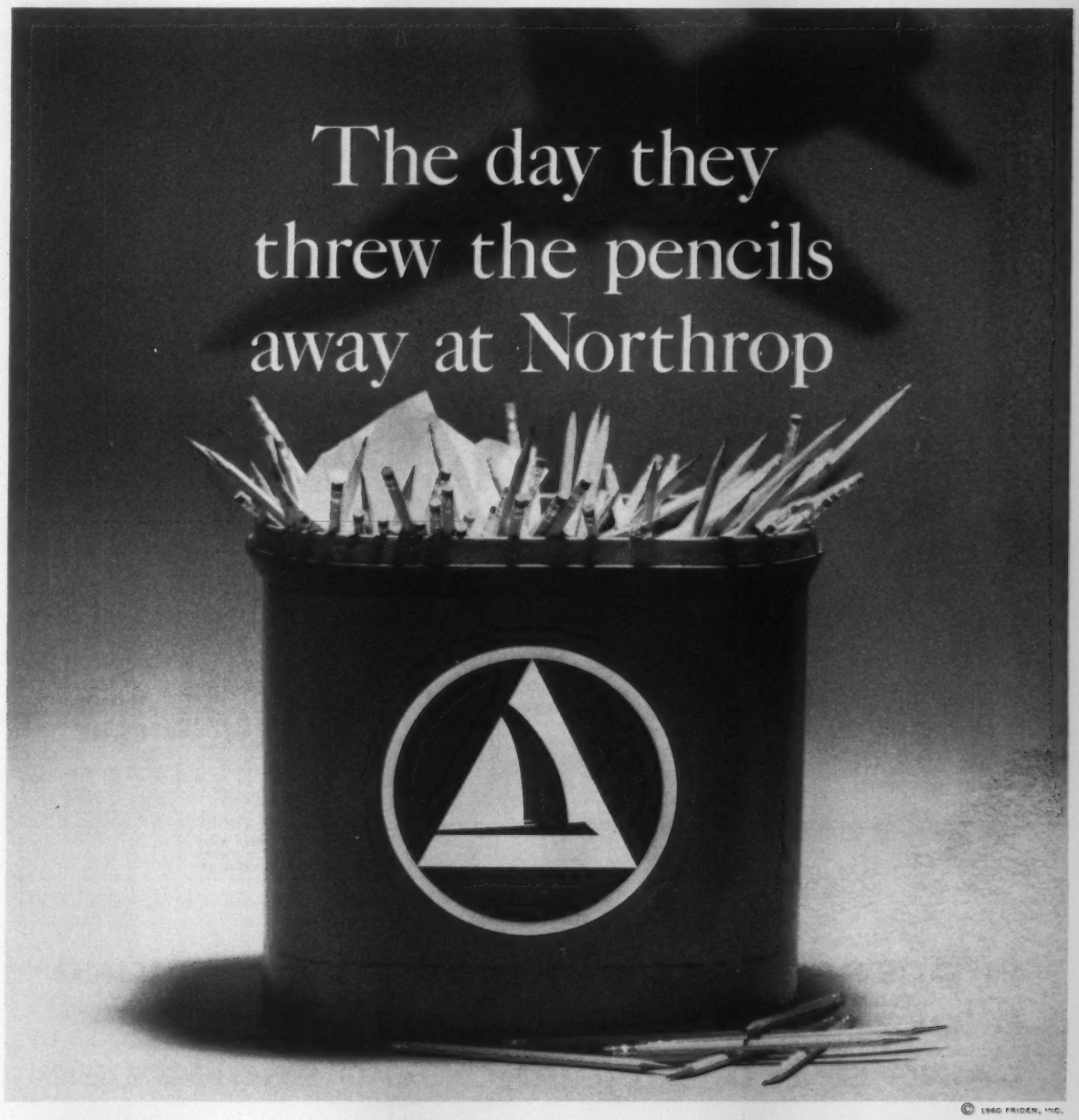
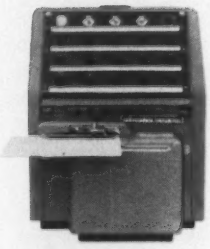
The day they threw the pencils away at Northrop



© 1960 FRIDEN, INC.



Northrop's Norair Division had a common and very costly bottleneck: internal paperwork.

The solution? *Automated data preparation* by means of a Friden Collectadata® System. Located in key plant locations, Collectadata transmitters report virtually all internal transactions—about 45,000 daily—to central Collectadata receivers which record them into punched paper tape. At day's end, the tapes are then fed into Norair's computer for high speed electronic processing.

Northrop estimates this *completely automated* system will eliminate *two boxcars of paperwork annually*. How much could Collectadata save you? Call your Friden Systems Man or write: Friden, Inc., San Leandro, California.

THIS IS PRACTIMATION: Friden specializes in the practical application of automation principles to source data preparation and processing.

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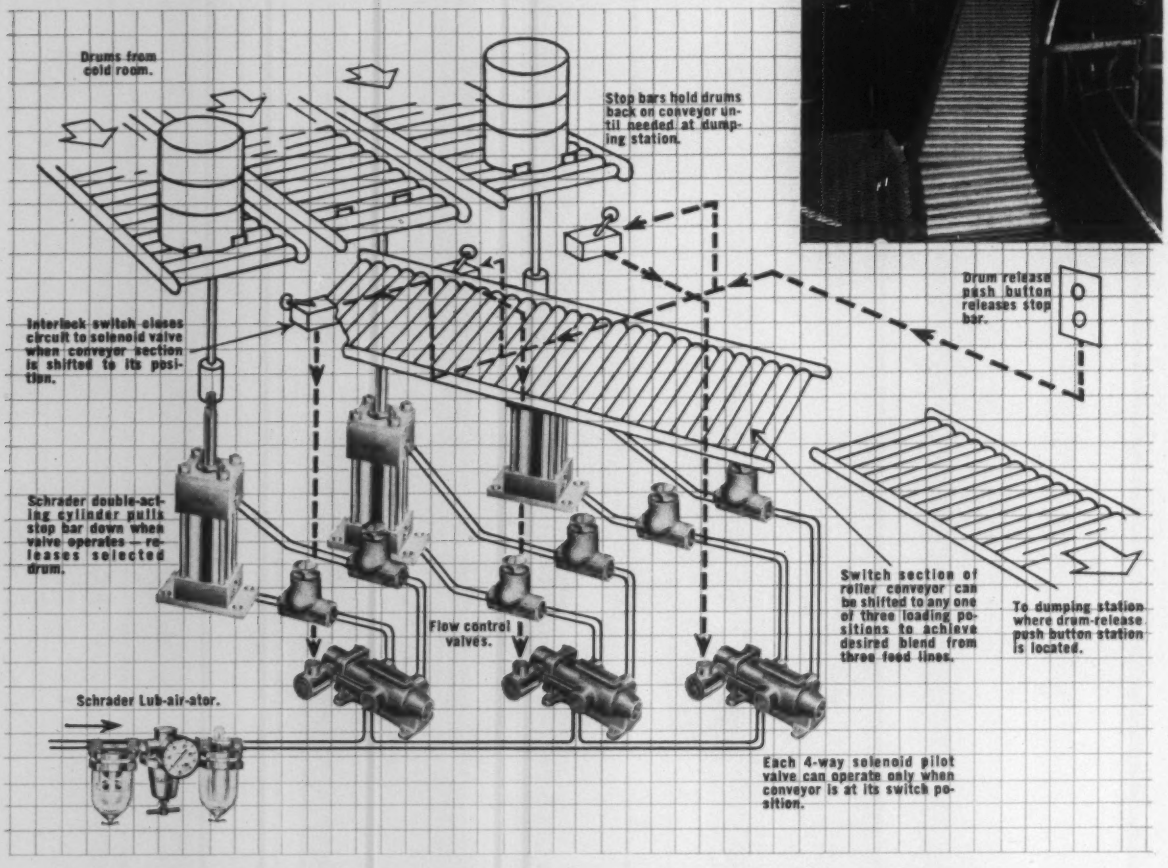
SALES, SERVICE AND INSTRUCTION THROUGHOUT THE U.S. AND THE WORLD

Processors automate even heavy work with air. In a complex frozen juice concentrate blending operation, Plymouth Citrus Products Cooperative, Plymouth, Fla., hooks up Schrader Air Products simply and economically to a gravity conveyor. Full 55-gal. barrels on feed sections roll down to stop bars and are selected in correct order and ratio for dumping. "The Schrader system performs well," says C. Byron Smith, plant manager. "We're handling 200 to 300 barrels a day on this selective conveyer, and could handle more."


Drums from cold room.
Stop bars hold drums back on conveyor until needed at dumping station.
Drum release push button releases stop bar.
Interlock switch closes circuit to solenoid valve when conveyor section is shifted to its position.
Schrader double-acting cylinder pulls stop bar down when valve operates — releases selected drum.
Flow control valves.
Switch section of roller conveyor can be shifted to any one of three loading positions to achieve desired blend from three feed lines.
To dumping station where drum-release push button station is located.
Schrader Lub-air-ator.
Each 4-way solenoid pilot valve can operate only when conveyor is at its switch position.

PROCESSOR AUTOMATES BACK-BREAKING CHORE WITH SCHRADER AIR PRODUCTS . . . GAINS SPEED, EFFICIENCY, BIG ECONOMIES

Solve difficult problems of handling, conveying and sorting, just like this company . . . with air! Versatile Schrader Air Products take punishing environments in stride, even corrosive atmospheres . . . Work together like magic on American production systems of many different kinds in hundreds of industries.

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Select from the full Schrader lines to plan your automation of machines. Your Schrader distributor can help you pinpoint what you need. For more data write:

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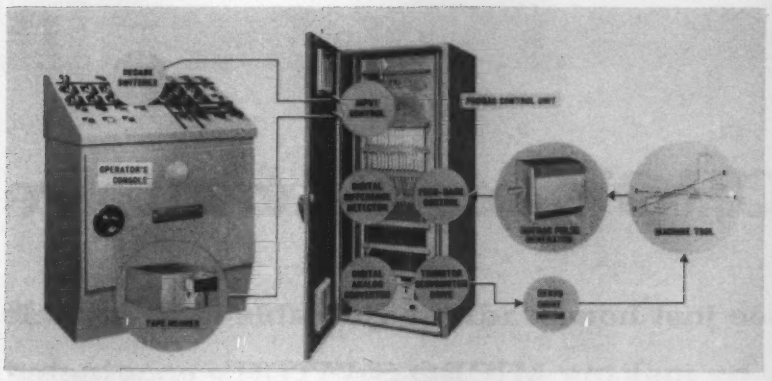

Numerical Control System

Programmed digital automatic control consists of five basic units: Operator's control, tape reader, Prodac control unit, Rotrac pulse generator, and drive motors. The control unit contains a servomotor control and a series of transistorized modules. Operating information is fed into the control unit by the tape reader. Position command information computed by the control is transmitted to a servomotor control apparatus, energizing the servomotor and setting the machine tool in motion. The control system controls one to five machine tool motions over a span of 999.999 inches and handles all auxiliary machine tool functions. Control of the machine motion is on a point-to-point positioning basis, with a typical electrical accuracy of ±0.0005 inch. Every machine motion is detected by a pulse generator which normally produces an electrical pulse for each 0.001 inch of machine movement. The position information is constantly fed back to the control unit where it is automatically compared to the programmed position. Any error energizes the servo drive control apparatus to correct machine position. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

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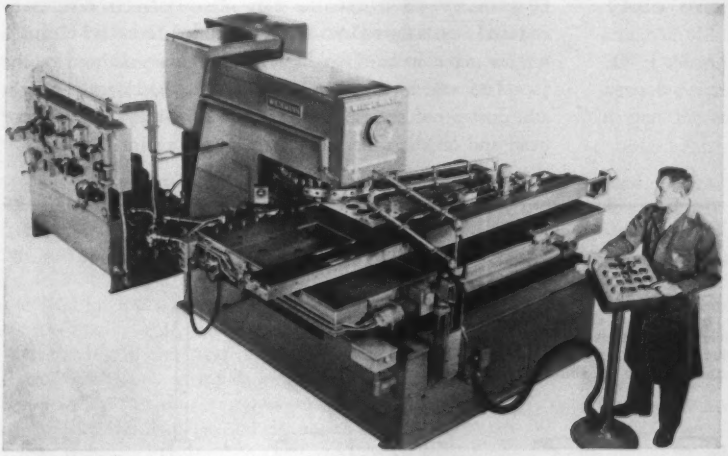

Tape-Controlled Turret Punch Press

Turret punch press features numerical positioning control, can automatically locate and pierce holes at a rate of 60 per minute. Model A-15 can pierce a 3½-inch diameter hole in 14 gauge mild steel. Sheets up to 3/16 by 30 by 48 inches can be handled. The 15-ton press operates at 200 crankshaft strokes per minute, and the table moves at the rate of 500 inches per minute. Turrets carry from 26 to 32 different punches and dies, each accurately aligned. Any set is rotated into piercing position as required upon command by the tape. Standard eight channel, one-inch wide punched paper tape, prepared on a tape making typewriter, is used. The tape contains three-place decimal dimensions for the X and Y centerline hole dimensions and turret station location as required for each hole. **Wiedemann Machine Co.**, Gulph Rd., King of Prussia, Pa.

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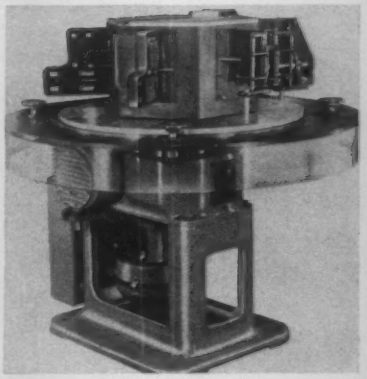
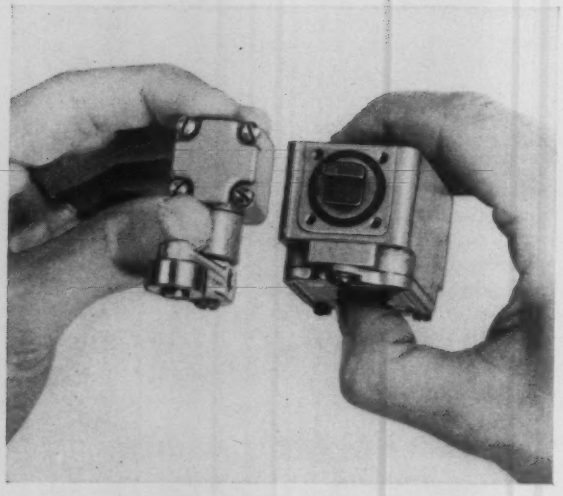


Assembly Machine

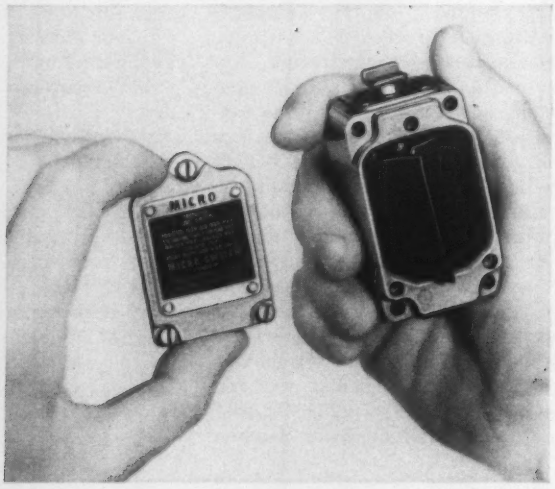
Rotary transfer machine has a 36-inch diameter dial with 12 positions. Each of the six integral cam actuated parts-placing stations, operated from the dial center, service two positions on the dial. Allowing one pair of stations for ejection of completed assemblies, the double-tooled machine can produce 120 five-part assemblies a minute while operating at a cyclic rate of 60 assemblies per minute. Some stations are of the slide type, which provide *push and guide* parts handling through a combination of horizontal escapement and vertical placing motions. Other stations are of the oscillating and reciprocating arm type and square motion type which utilize vertical escapement, horizontal positioning, and vertical placing for *pick and place* parts handling. Different strokes can be used at each station. One or more of the integral stations can be omitted and externally mounted work stations installed and driven from below by a chain which provides

Check MICRO's big advantage

See just how readily adjustable–and durable by making MICRO SWITCH's convincing



In just twenty seconds check the easy adjustability. Remove just four screws, lift actuator head, turn the plunger shown inside the embedded "O" ring seal. Replace actuator head facing in direction desired —front, back, left or right. Roller arm also has 360-degree adjustability.

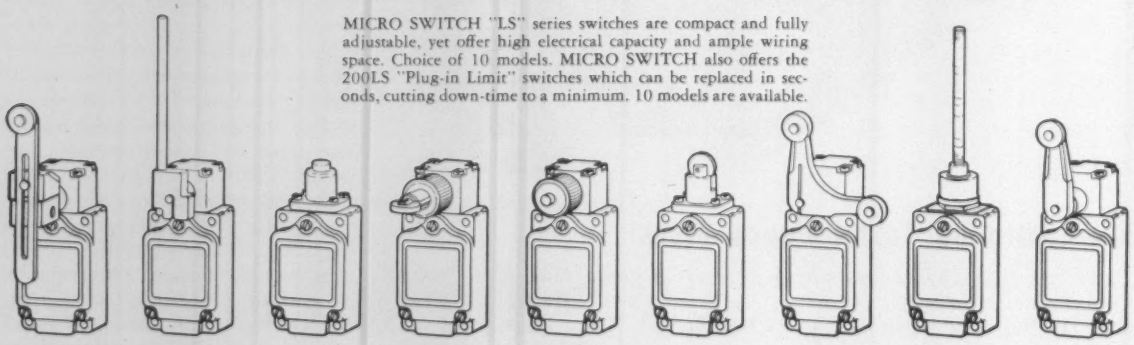


It's easy to remove the faceplate for terminal connections in 20 seconds! Captive screws make it quick and easy to remove and replace the faceplate whenever wiring changes are necessary. Oiltight and dust-proof seals on the faceplate, beneath the actuator head and on the roller arm shaft, guard against fouling.

---

9 Different Actuators for Cost-Cutting Versatility

MICRO SWITCH "LS" series switches are compact and fully adjustable, yet offer high electrical capacity and ample wiring space. Choice of 10 models. MICRO SWITCH also offers the 200LS "Plug-in Limit" switches which can be replaced in seconds, cutting down-time to a minimum. 10 models are available.



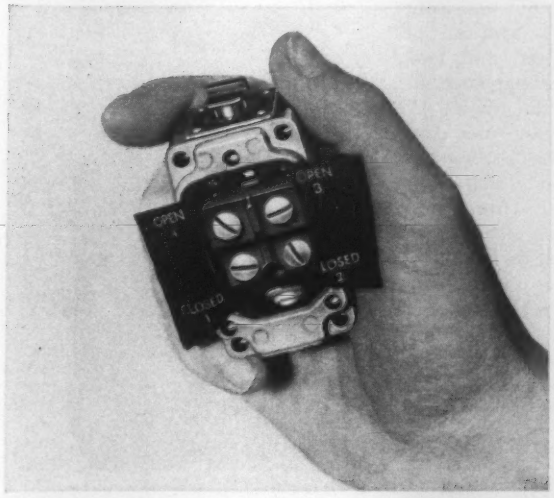
ADJUSTABLE ROLLER ARM | ROD ACTUATOR | IN-LINE PLUNGER | SIDE ROLLER PLUNGER | SIDE PUSH PLUNGER | ROLLER PLUNGER | YOKE ACTUATOR | COIL SPRING | ROLLER ARM ACTUATOR

H HONEYWELL MICRO SWITCH Precision Switches

–rugged simplicity!

a limit switch can be,

45-second screwdriver test



Check the advantages of MICRO's basic switching unit in just 5 seconds! Stepped design allows extra space for easy wiring. Precision switching unit is self-contained, factory adjusted and replaceable. Heavy-duty #8 screw-type terminals.

ACTUAL SIZE

The rugged simplicity of the MICRO SWITCH "LS" series offers many advantages where high adjustability, compactness and heavy-duty electrical capacity are needed. As you've just proven yourself, these switches can be fully adjusted in a matter of seconds, making change-overs much simpler and far less costly. Compact in size, they fit in many places too small for any other fully adjustable limit switch. Yet they are big in electrical capacity . . . made to handle the same electrical loads as much larger switches. The rugged aluminum-alloy housing protects the precision switching unit from physical damage, and the entire unit is completely sealed, oiltight and dust-proof to prevent fouling.

The many time and money-saving features of this switch are true of the entire family of MICRO SWITCH limit switches. Rotary-actuator heads may be mounted in any of four positions. All models of rotary-actuator switches can be set to be operated electrically in both directions; or only to the left or right. Lever arms adjust through 360 degrees. Roller levers may be faced in either direction. And roller plungers can be faced at 90° increments.

See the Yellow Pages for the name of the nearby MICRO SWITCH authorized distributor or branch office.

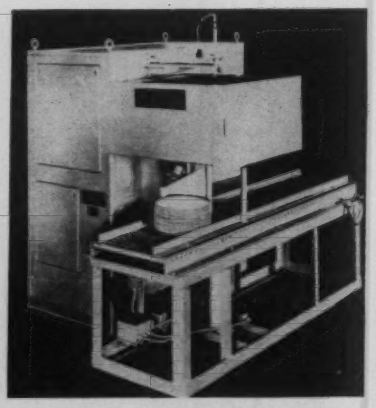
Call your nearby authorized MICRO SWITCH Distributor and ask him to show you the inside story. Ask for Catalog 84.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

timed rotation of the idler shafts. Machine uses a high speed index table (designated Intermittor) with a roller gear drive cam-indexing mechanism. The power assembly is pivot mounted in the base and can be swung out for maintenance without disassembly. **Ferguson Machine Corp.**, 7818 Maplewood Industrial Court, St. Louis 17, Mo.

Circle 417 on Page 19



Induction Heater

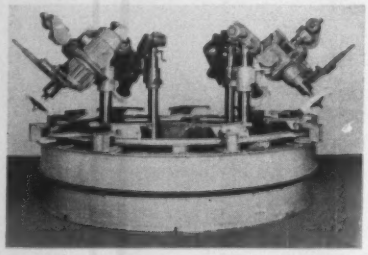
Induction heater can anneal circular, rectangular, or oval aluminum blanks ranging from 4 to 30 inches in diameter. It can heat the blanks in 12-inch stacks and thickness of material can range from 1/32 inch on up to whatever thickness is required. The heating time can range from a minute per stack in the smallest diameter to 40 minutes maximum for the 30 inch diameter. In operation, the blanks are stacked on the conveyor and positioned under the heating coil. The *Start* button is pressed and automatically the positioning guides retract, the stack is hoisted into the coil, and the coil is energized for a pretimed cycle. When the blanks are up to temperature the coil is de-energized and the stack is automatically returned to the conveyor. The annealed stack is moved to the cooling conveyor while another stack is loaded. The unit in the illustration can heat 1000 pounds per hour to 850F and is rated at 125 kw. Power supply is 440 v, 1 phase, 60 cycles. **Ajax Magnethermic Corp.**, Youngstown, Ohio.

Circle 418 on Page 19

Chucking Turret Lathe

Automatic chucking turret lathe uses a Westinghouse punched paper tape control. It is a program digital automatic control comprising logic, scanning, and control of functions such as speed and feed selection, and program sequence direction. Designated the Model 1F Fastermatic, the machine uses conventional turret lathe tooling on one job for cast iron clutch hubs with two operations (front and back of a part) completed with each complete index of the hexagon turret. Features of the machine include a 2-speed motor and cross slide tool relief. **Gisholt Machine Co.**, 1245 E. Washington Ave., Madison 10 Wis.

Circle 419 on Page 19



Polisher & Buffer

Automatic polishing and buffing machine features a rotary conveyor, is adaptable to finishing parts such as automobile moldings, refrigerator trims, and stove trims. The 12-foot diameter unit shown can finish angular-shaped automotive trim at a rate of 350 pieces per hour. Machine consists of a rotating outer conveyor ring and a stationary inner ring. The parts are loaded and unloaded from one position on the periphery of the machine. Workpieces are mounted on fixtures on top of an 8-inch wide table on the rotating ring and move past buffing wheels mounted on adjustable lathes spaced around the inside of the conveyor. Cam rails mounted on the stationary inner ring can operate in conjunction with pivoted fixtures to move the parts to controlled positions at various stations around the periphery of the machine. The number of work fixtures mounted on the table varies with part shape, length, and finish requirements. Up to six adjustable lathes can be placed inside the rotary conveyor, with an equal number mounted around the outside if required. **Acme Mfg. Co.**, 1400 E. Nine Mile Rd., Detroit 20, Mich.

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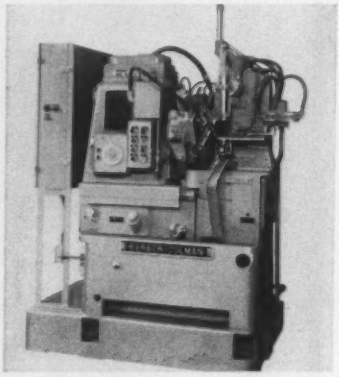
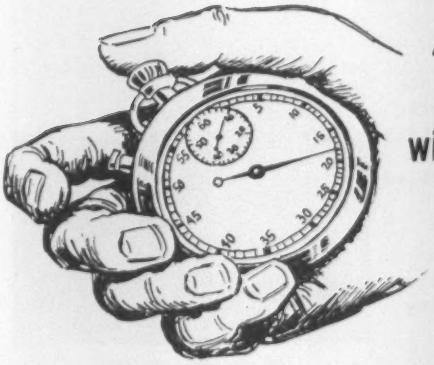


Hobbing Machine

Automatic cycle of hobbing machine includes carriage feed, retraction after the cut, and rapid carriage traverse to the starting position. The machine is automatically loaded when a shuttle places a pair of blanks under the hydraulically actuated tailstock, where they are locked in position against the serrated driver. After the cut, the shuttle unloads the finished work and picks up the next two blanks. Feature of the automatic cycle is an automatic hob-shifter. It can be set to operate after each cycle, or after a certain number of gears has been cut. Maximum hob speed for Model 4-6 is 614 rpm. Maximum feed is 0.150 inch per revolution of the work; maximum work diameter is 4 inches, maximum face width is 6 inches, maximum hob diameter is 3¼ inches. **Barber-Colman Co.**, 1400 Rock St., Rockford, Ill.

Circle 421 on Page 19

split-second response!
more work per hour!



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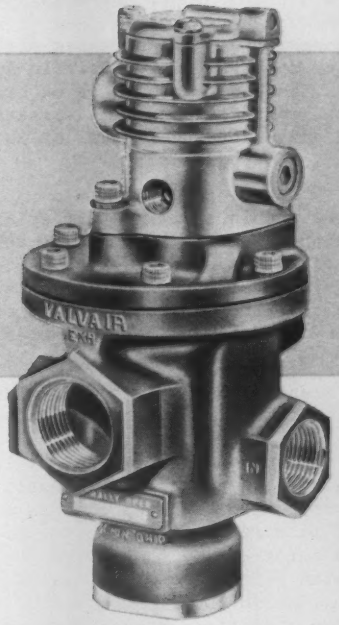
- **instant-action control • air-cushioned poppet**
- **multi-million cycle dependability • JIC pilot**



HI-SPEED INLINE with integral pilot, 2- or 3-way, NO or NC, 3/8 to 1¼ in. NPT.

Short poppet travel in Valvair's HI-SPEED INLINE provides maximum flow almost instantaneously. This shortens machine cycle time . . . lessens brake and clutch slip . . . provides more accurate cuts on high speed cut-offs . . . decreases set-up time . . . minimizes drift, for safer operation.

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DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8110-3

Circle 706 on Page 19

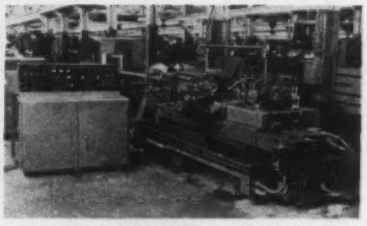
(Advertisement)

FOR IMMEDIATE RELEASE

Press Release from: JONES & LAMSON MACHINE COMPANY, Springfield, Vermont, U.S.A.

for all publications, on machines for N M T B A Exposition.

J&L Booth #839 at the NMTBA Exposition in Chicago will include several machines which represent the latest advances in metalworking automation. Highlights of the J&L exhibit will be an all-new, completely automatic, electro-mechanical machine; and the world's first production model of the Jones & Lamson Numerically Controlled Turret Lathe.

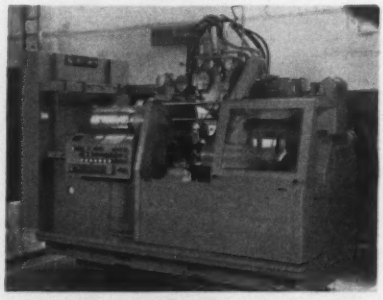


J&L Numerical Tape Control Turret Lathe

Among other operations, you will see multiple tooling on a two-dimension turret lathe tracing unit, and the remarkable Jones & Lamson auto-threader, which provides completely automatic cycling for single-point thread chasing.

Also in operation will be three different variations of the all-new family of Model 30 Single Spindle Automatic Turning and Tracing Lathes. The basic machine is of bridge-bed design for maximum rigidity, and offers extreme versatility of tool motion, ease of loading and unloading (manual or automatic), as well as ideal conditions for chip removal.

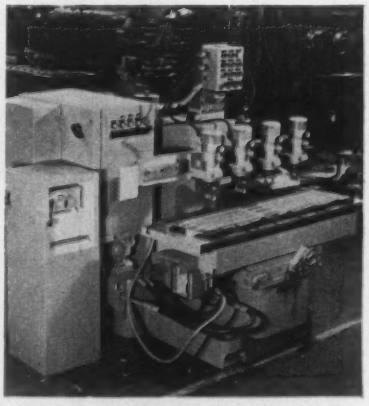
The three machines will be set up as follows: One is a Multiple Slide Single Spindle Automatic (machining a production run of crankshafts). Another is a 60° Automatic Tracing Lathe (performing high-production work on steering knuckles). The third machine will demonstrate multiple tooling of Two-Dimensional Tracing on a series of different sized gear blanks.



J&L 60° Model 30 Automatic Tracing Lathe

All of these machines feature a wide range of spindle speeds (up to 32), with automatic speed and feed change during a cut. A variety of components may be added to the base machine to meet specific requirements demanded by the individual customer's work. For instance, a rugged 6" hydraulic ram tailstock is mounted on the lower bed for between centers work. Multiple tooling may be applied to a rear forming slide, or a rear facing, forming and turning slide - also mounted on the lower bed. Two bevel facing, or necking slides (one light-duty, one heavy-duty) are available for mounting on the front side of the lower bed. The upper bed may carry a multiple-tooled turning slide, a 60° tracing slide, or a 180° (two-dimensional) tracing slide. The two-dimensional slide is hydraulically controlled, and may be multiple-tooled for tracing operations using any one of eight different tool travel cycles - each of which controls tool motions through a full 180° of travel.

Two different headstock transmissions are available (16 speed or 32 speed) as well as two different spindle noses (6" A-1 or 8" A-1). The machine comes in three standard bed lengths - 24", 48", or 72". Controls are unique, reliable and extremely accessible. On re-order, for instance, set-up is accomplished in a matter of minutes simply by setting the graduated dog rings on the conveniently located control drum.

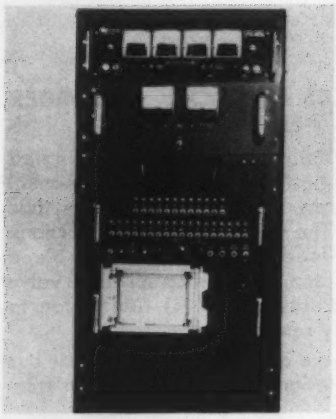


J&L Tape Controlled Positioning Table

J&L's 20" x 20" Positioning Table will also be in operation under one inch, 8 channel tape control, with electronic hydraulic servo control for end point positioning. The Positioning Table will be set up in conjunction with a Standard Post Drill, to demonstrate the speed, accuracy, and minimum set-up time required with tape control on small or long-run production.

"The Man Who Needs a New Machine Tool Will Find it in Booth #839"

Circle 701 on Page 19



Alarm System

Solid-state monitor alarm system, applicable for process control and power generation, can verify the condition of 30 stations with an accuracy of one part in a thousand. All 30 channels are examined in less than 0.3 seconds. In operation, signals from transducers representing temperatures, pressures, liquid flows, and displacements are fed to the alarm system, which is designated Signal Sentry. The permissable values for each station are punched in advance into an IBM card. When the card is inserted in the front of the system, it checks each station against the prescribed values and provides audible and visual information and electrical outputs when a station is about to exceed or has exceeded its allowed tolerance. **Franklin Electronics Inc.**, 5901 Noble Ave., Van Nuys, Calif.

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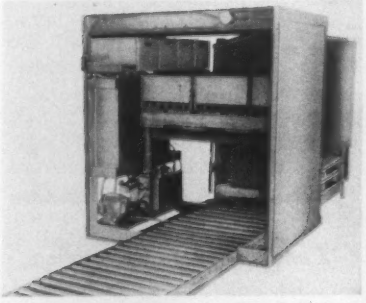

Pallet Loader

Model 100-RS can stack cartons, soft drink cases or multiwall bags onto pallets at rates of up to 33 units a minute. The machine can automatically adjust to load any 36-inch wide pallet. It is also self adjusting to handle packages of any height. The loader contains its own air compressor, is pneumatically operated and electrically controlled. For special applications, the machine can be hydraulically powered. Package infeed conveyors can be either powered or gravity rollers. The pallet magazine holds up to 15 pallets which can be either two-way or four-way entry.

In operation, packages received from the processing line are automatically formed into a row by a pneumatically operated right angle pusher. When a complete row has been formed, the row feeder positions it on the transfer table which moves into position over the pallet, then recedes as the stripper bar gently places the row on the pallet. The stripper bar remains in position, even after the transfer table has withdrawn, compacting the cases and holding them accurately in place. Simultaneously, the next row is being formed on the row feeder. When a tier has been completed, the pallet indexes down one package height in position for the next layer, automatically adjusting to packages of any height. The transfer table retracts to receive the next row. Loaded pallets are automatically lowered to the outfeed conveyor as the pallet magazine feeds an empty pallet into loading position. **Engineered Handling Systems, Div., Wiretyer Corp.**, 65 Leliarts Lane, East Paterson, N. J.

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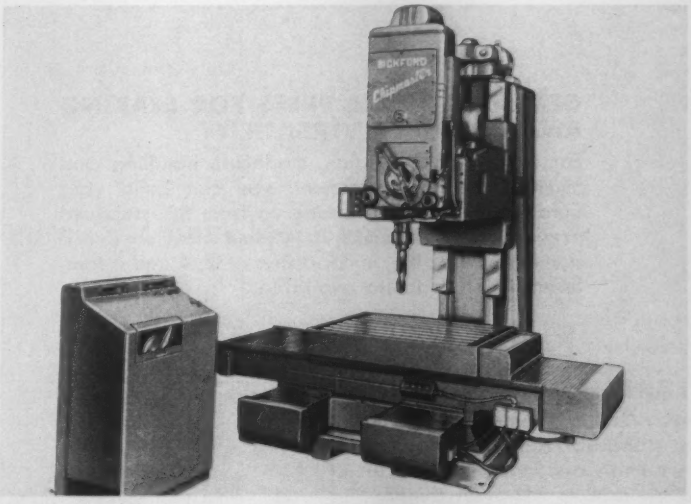
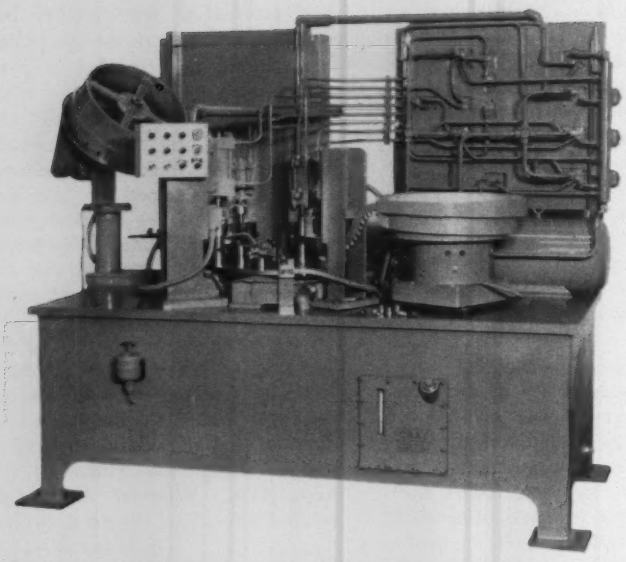


Drilling Machine With Tape-Controlled Table

Drilling machine with tape-controlled positioning table can accommodate loads up to 5 tons at speeds of 360 ipm. The drilling machine has a preselection of 36 speeds and 18 feeds and automatic hydraulic gear shifting. Positioning accuracies of the table are to ±0.001 inch, with repeat positioning to ±0.0005 inch. Working surface is 38 by 50 inches and table travel is 32 by 44 inches. Dimensional data can be entered into the system by two methods: Automatically on punched tape prepared by the programmer or manually by the operator from the control console keyboard. The table operates in all four quadrants and accepts either plus or minus commands in either the *X* or *Y* axis or both. Traversing (at a speed of 360 ipm) and final positioning (at a speed of 20 ipm) can take place in both axes simultaneously. The reference point can be established by the programmer anywhere within the travel of the table. **Cincinnati Bickford Div., Giddings & Lewis Machine Tool Co.**, Cincinnati, Ohio.

Circle 424 on Page 19



ASSEMBLES 41 SHOCK ABSORBER PISTONS PER MINUTE

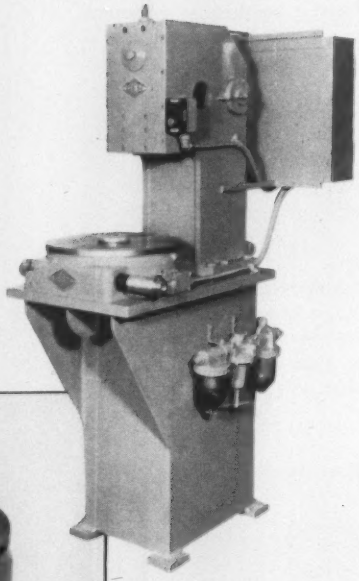
This Gray-designed, Gray-built automated assembler knocks the props out of manual assembly costs; paid for itself in less than six months. The unit performs four functions: (1) Hopper-feed the piston; (2) Coin a bleed slot in the piston; (3) Feed compression valve and temporarily stake; (4) Curl piston to permanently retain valve.

Whatever your assembly problem, Gray has probably designed a machine not far from your needs.

FOR FAST, ACCURATE PRODUCT ASSEMBLY

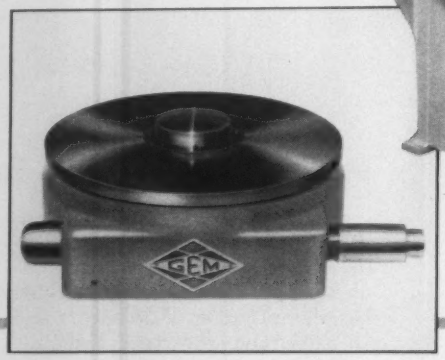
GEM AIR TOGGLE PRESS FOR STAKING AND ASSEMBLY VERSATILITY

For moderate production, moderate handling and minimum capital investment, you can build your automatic assembly machine up from this standard press. It's available with or without the Gem precision indexing table, in capacities of 2, 4 and 6 tons. Special fixturing also available.



INDEXING TO ±0.001"

Geneva Motion Gem-17 Indexing Table standardizes automation on your assembly and machining operation . . . drilling, tapping, riveting, spinning, staking, knurling, chamfering, welding, screwdriving, stud driving and gaging to the speed and accuracy required. Indexing speed up to ½ second; takes 1,000# loads and has anvil capacity of 30 tons.



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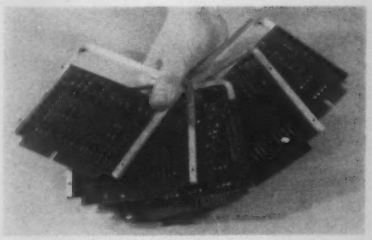
gem

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems.

For detailed information and literature, use card page 19.

The master station demonstrator of the solid-state supervisory control equipment is shown at the left. Operating lamps on this station provide the operator with indication and control at a glance. The remote station demonstrator model is shown at the right. Lamps shown on this station represent actual equipment such as power circuit breakers or oil-type line valves located in the field.



Plug-in logic elements (composed of transistors, diodes, resistors, and capacitors) direct and receive operation messages to and from remote apparatus through a master station-remote station system.

Supervisory Control Has Solid-State Components

SOLID-STATE supervisory equipment is designed for use in electric utility systems for generating station metering and control, in industrial power systems for monitoring and control, and in pump valve control for telemetering pressure, rate of flow, and temperature. The equipment, developed by **General Electric Co.**, Schenectady 5, N. Y., will operate on any two-way communication channel, including telegraph-grade leased-wire. Transistorized logic elements direct and receive operation messages to and from remote apparatus through a master station-remote station system. The elements in the system are plug-in cards utilizing transistors and diodes.

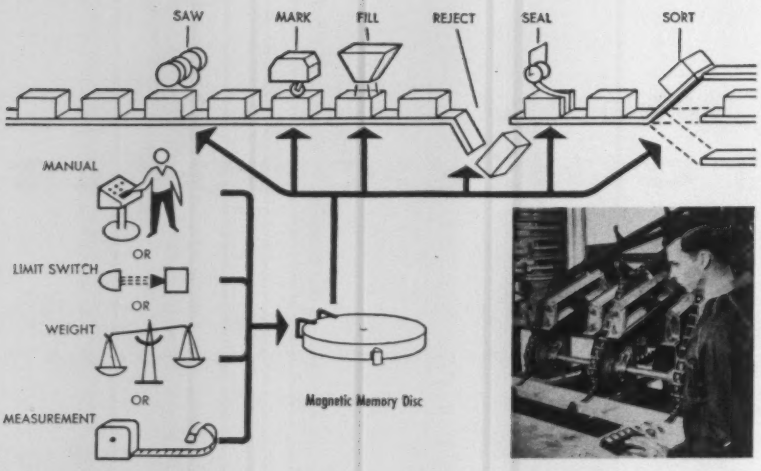
In operation, the cards take impulses from the master station which are originated by a touch of a button or by a tape-controlled electronic connection. Signals are converted into an outgoing code, and directed over the proper communication channels to remote stations. The outgoing code is translated into the form of pulses and pauses with the operating intelligence carried by the pauses. Each control point has its own code that cannot be mistaken by the equipment for another code. A point on the master station consists of a grouping of indicating lamps and a key to initiate selection. The lamps indicate when the code or point has been established between the master station and the remote station; when action has been initiated and completed; and an alarm indication for each specific point. Composed of both pulses and pauses, the code is less apt to cause distortions that might cause misoperation. If so much distortion occurs that it adds or subtracts a pulse, the equipment locks out and resets itself. When communication is first established between the master and remote station by selection of a point, there is an immediate and automatic check-back which tells the equipment that a communication code has been correctly established.

Circle 425 on Page 19

Magnetic Disc Provides Time Delay

MEMORY system, designated Magnastat, is developed around a magnetic disc that is adaptable to a variety of applications in materials handling where a time delay factor is present. It provides control of grading, sorting, filling, marking, wrapping, stamping, or trimming operations on conveyed products of any type and size. The system is activated manually by limit switches or by weight or size of the conveyed material.

In operation, an input coil records control decisions as magnetic im-



pressions. The impressions are stored on the memory disc and at the point of control (a later stage in the production line) an output switch detects the magnetic record. An actuator is signalled to implement the choice. Once the control decision has been executed, the magnetic area on the disc is erased, and the clean disc area is ready to receive the next series of magnetic control decisions. The disc is capable of handling an infinite number of repeat magnetic impressions without interruption. For example, in a lumber field application (shown in photograph), the system is used with sawmill trimmers. An operator is behind a pushbutton control console. As rough-cut lumber passes on the chain, the operator decides which saw in a battery is required by pushing a button while the board is in front of him. This action automatically operates the correct saw in the battery of trim saws, making the proper cut when the board reaches cutting position. **Republic Electric & Development Co.**, 2627 Western Ave., Seattle 1, Wash.

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Air/Hydraulic Feed

Available for punching, clamping, riveting, shearing or pressing metals or plastics, air/hydraulic feed requires no pumps or motors. It is

powered by a shop's air supply, and there is no bounce at point of breakthrough or when load is released. Trigger valve actuators or solenoids enable any sequence of operations to be performed automatically. **Superior Controls**, P. O. Box 436, Commercial Rd., Crystal Lake, Ill.

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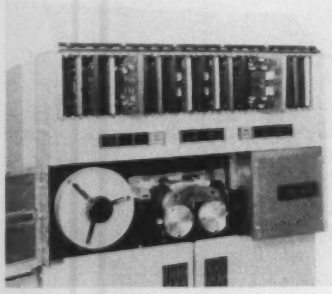

Tape System

High-speed digital tape system, Model TD 100, is capable of character transfer rates of 300,000 characters per second. A total storage of greater than 300 million bits can be achieved on one 6-inch file reel of 1-inch wide magnetic tape. Access times of twenty seconds are achieved by the use of a dual-bin tape storage transport design with *Start* and *Stop* times of less than 1½ milliseconds. Loading and unloading of the file is performed automatically by means of a permanent threading leader and quick disconnect file tab. Average loading and unloading times are 60 seconds or less. Digital densities of 1000 phase modulation bits per lineal inch, and higher, are possible through use of a tape slot guide which holds total skew to a maximum of 3 microseconds across 1-inch tape moving at 150 inches per second. Speeds to 300 inches per second can be achieved. Read and write heads are available with from one to 32 tracks as required by the application or computer format. **Shepherd Industries Inc.**, 103 Park Ave., Nutley, N. J.

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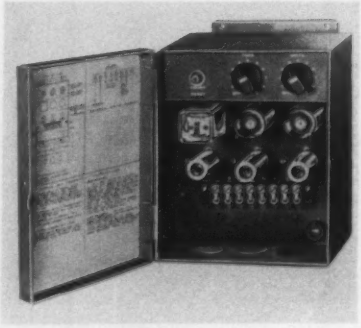
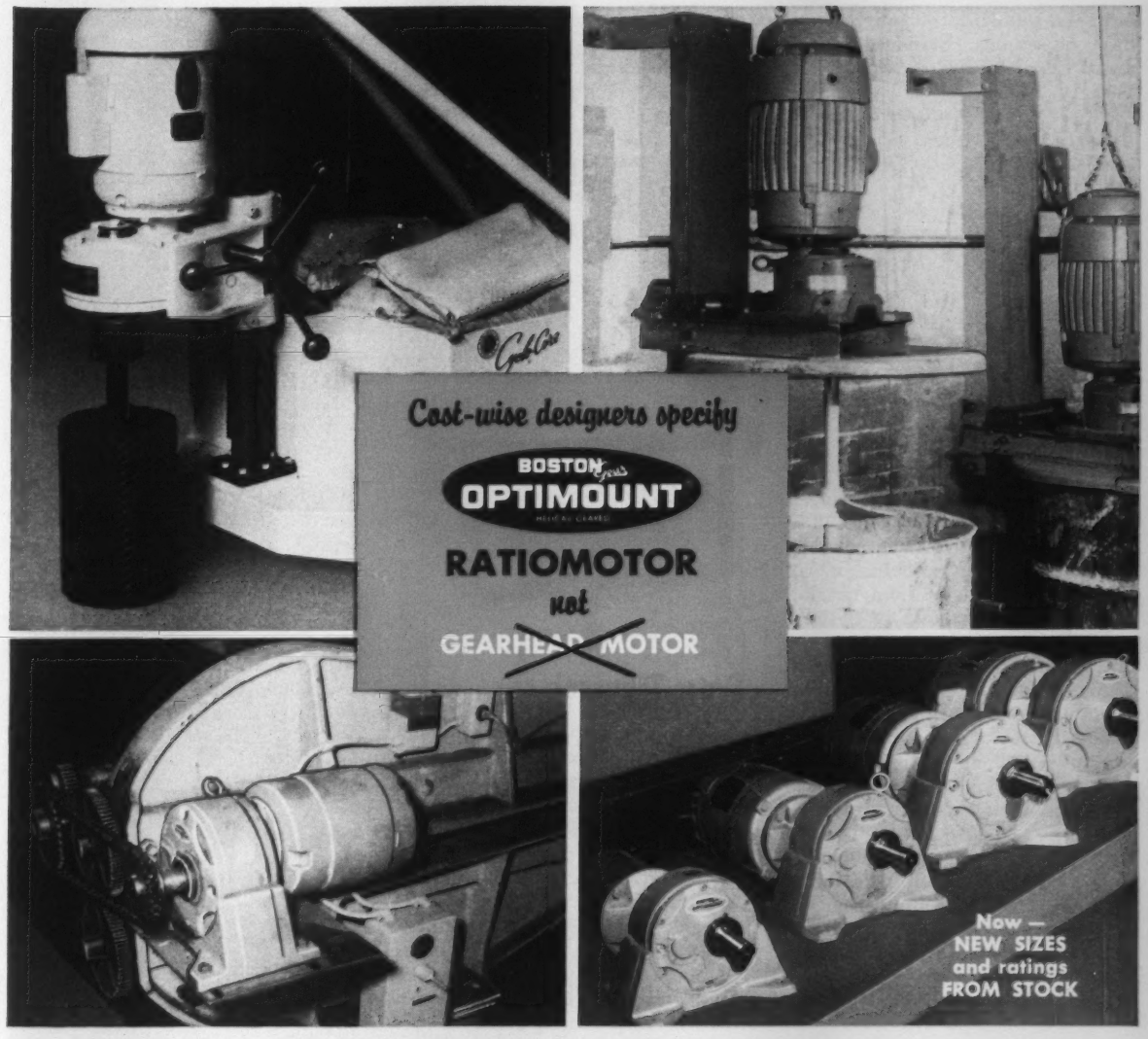


Electronic Counter

Instrument designated Tally-Count is applicable for batch counting, linear measurement and cut-off, container filling, sheet counting, and machine cycling. Designed for automatic control of industrial processes, Model 242 actuates equipment at any pre-set count from 2 to 100, at speeds faster than 1000 operations per minute. In operation, the batch count desired is set on direct-indicating switches. When this count is reached, a control relay closes momentarily (100 milliseconds) to operate any external device. The counter instantaneously resets to zero and continues the counting process without a loss of count. Actuation of the counter is by external contacts (limit switch, magnetic switch, toggle switch, relay). Photoelectric controls may be connected to the unit so that items can be counted without physically contacting the product. A separate optional time delay unit may be connected to the counter to extend the operate time of the control relay



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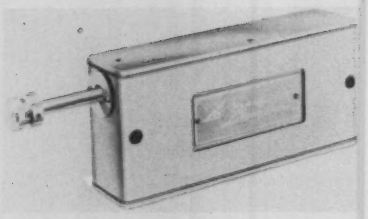
— STANDARDIZATION PAYS —

Circle 708 on Page 19

from the standard 100 milliseconds up to 60 seconds. **Standard Instrument Corp.**, 657 Broadway, New York 12, N. Y.

Circle 429 on Page 19



Linear Controls

Line of self-contained packaged units is designed for control of strokes of air and hydraulic cylinders and other linear machine movements. The cast aluminum housing unit is ready to operate on the machine by one rigid mounting of the entire unit, only one electrical lead, source of power. Enclosed within the aluminum housing are reciprocating means for actuating single or multiple numbers of limit switches. Units featuring two reciprocal switch actuating means are available in ¼ to 4, 8, 12 or 18 inch strokes, both in medium and heavy duty models. Special units featuring up to 10 switch actuating means in a single packaged unit are also available. **Paramount Textile Machinery Co.**, 131 S. Wabash Ave., Chicago 3, Ill.

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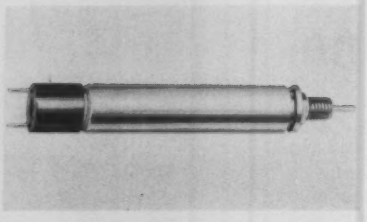
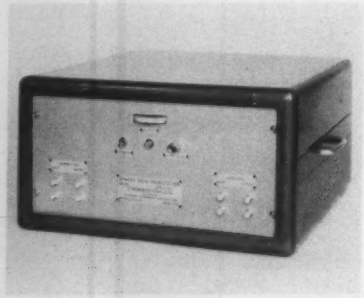


Instrument Solenoid

Solenoid designed for business machines, computers, data processing, and instrumentation operates on 6 to 110 v dc with power requirements of 3 w continuous or 6 w intermittent duty. Unit lifts up to 8 ounces intermittent or 6 ounces continuous duty, and has been tested to 20 million cycles. It has a stroke up to 5/16 inch push or pull type. Enclosure is steel shell; terminals are plug-in or lead types; mounting is 4-28 threaded bushing. Size is ½ inch maximum diameter, 3½ inch long. **Guardian Electric Mfg. Co.**, 1550 W. Carroll Ave., Chicago 7, Ill.

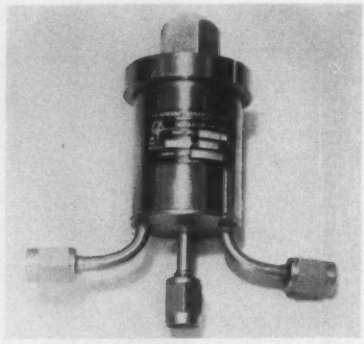
Circle 431 on Page 19



Data Transceiver

Binary data transceiver makes it possible for electronic computers and other high speed data handling devices to be connected directly to each other over regular commercial telephone lines, transferring information at a rate of 2400 bits per second. Feature of Model S-C 301 is modulation method which minimizes errors due to impulse noise, phase distortion, frequency translation, and other transmission problems normally encountered on wire line facilities. The input signal may be either polar or impulse type binary information. The transceiver accepts the data in the form of a serial train of pulses, shapes the pulses, and modulates a subcarrier frequency. No synchronizing signals are required, as the receiver portion of the transceiver has an automatic frequency control system for automatic synchronization at any bit frequency between 2350 and 2450 pulses per second. Higher or lower bit rates can be provided on special transmission facilities by substituting plug-in components in the transceiver. Full duplex operation between two transceivers is possible if a four-wire circuit is available. **Stromberg-Carlson, Div., General Dynamics Corp.**, 100 Carlson Rd., Rochester 3, N. Y.

Circle 432 on Page 19



Instrument Regulator

Unit is designed for industrial reference pressure applications. It can withstand temperatures to 1000 F. Regulated pressure is adjustable from 2 to 17 psia, and is within ±0.1 psi of set pressure at temperatures ranging from −65 to 600 F. The regulator is adaptable to pressures to 100 psia without changing the basic unit. Model 415830 features metal-to-metal seals and one moving part. **Gladden Products Corp.**, 635 W. Colorado Blvd., Glendale 4, Calif.

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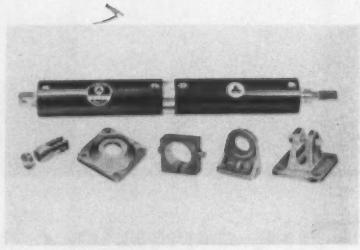
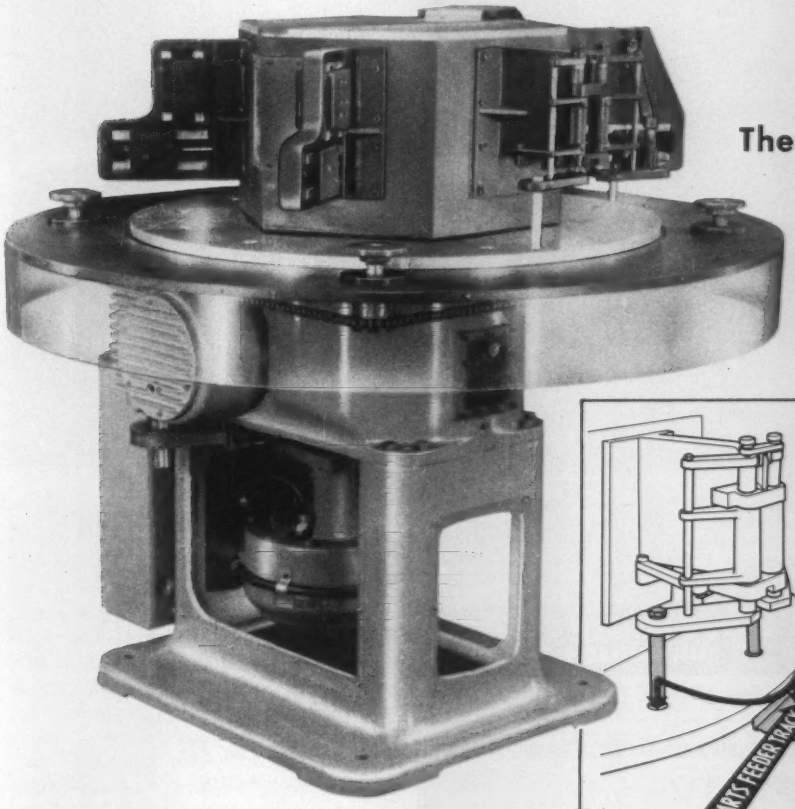


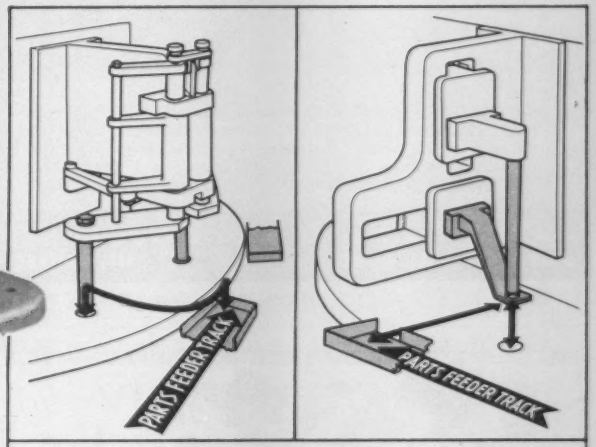
Tandem Cylinders

Line of tandem cylinders is available in bore sizes of 1½, 2, 2½, 3, and 4 inches in lengths up to 80 inches. A choice of mount is offered. They feature two pistons mounted on one common rod and are designed to provide the advantages of hydraulic control to an air operated cylinder. Hydraulic fluid can be used either in the front cylinder or in the center section of the unit without a make-up chamber. Speed control is obtained by simply piping flow control valves in series with the two ports used for the hydraulic section. By using pressure in both sections the usable

A NEW APPROACH to AUTOMATIC ASSEMBLY...



The machine tool concept to reduce equipment costs



Two of the standard cam actuated "pick & place" and "push & guide" stations. Each serves two dial positions. Shaded areas indicate those components attached by the user.

For the first time, medium size plants can employ automatic assembly to compete with large scale manufacturers because high volume is no longer a prerequisite to automatic production.

Ferguson's new approach to automatic assembly problems provides a standard rotary transfer machine complete with work stations that furnish parts placing motions right to the dial. The user only adds minor parts holding and positioning devices designed to conform to his production items. At the end of a production run *he changes set-up, as he would for any machine tool*, for operations on a different assembly.

Low initial cost of this standard machine means a fast pay-off on investment. Design versatility makes it adaptable for many uses and guards against obsolescence. And, as with any quality production machine tool, it is built for year-after-year performance with only normal maintenance practices.

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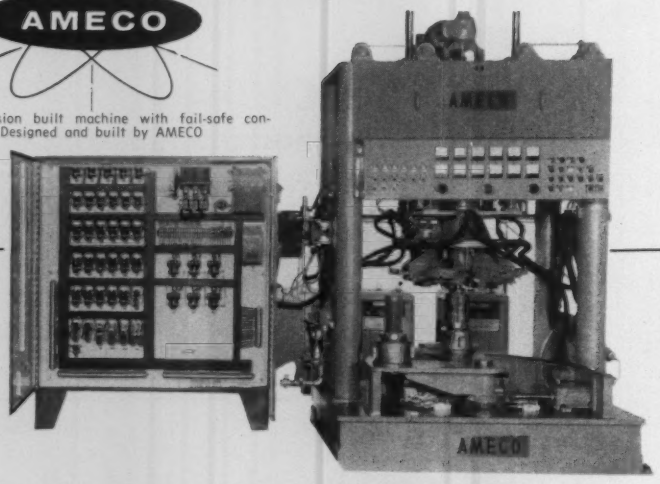
AMECO

STATOR PACK WELDER

Precision built machine with fail-safe control. Designed and built by AMECO



Specifications: Welds stator packs from 4½" to 6½" dia. and up to 8" long. Equipped with 6 TIG torches mounted on a ring to allow for either 6 or 12 welds. 2-station, 3-position index table for load, weld and unload. Produces 600 1½" high stacks in 1 hour. Write for Bulletin #360, which includes complete details and specifications.

AUTOMATION MACHINES & EQUIPMENT CO., INC.
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Circle 710 on Page 19

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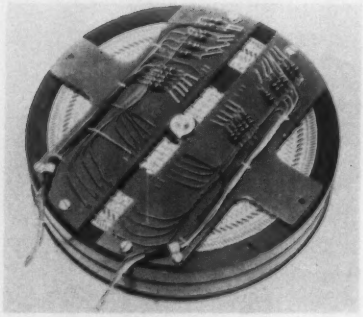
force available is twice as great as the force obtainable from a standard cylinder of the same bore size. This feature permits their use in spaces too small for larger bore cylinders. **Allenair Corp.**, 255 E. 2nd St., Mineola, N. Y.

Circle 434 on Page 19



Shaft Position Encoder

Encoder designated ADC-5-BCD (1000) is applicable to machine tool control, plotting tables, film readers, and other data logging uses. Features of the device include a self-selecting V-brush technique, which provides a completely unambiguous output without using logic circuitry, and a split-bit technique, which permits incorporation of the high-resolution encoder into a small package. It is capable of 100,000 counts in 100 turns of the input shaft. **Norden Div., United Aircraft Corp.**, Milford Dept., Wiley Street, Milford, Conn.

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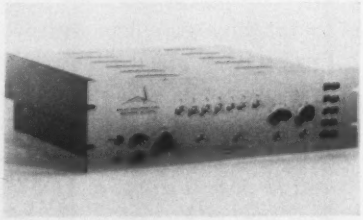

Pulse Pattern Generator

Unit designated Uni-Bloc Model 3-201 pulse pattern generator, a fully-transistorized test instrument, provides simulated input data words for data-processing systems and magnetic data-storage units. The in-

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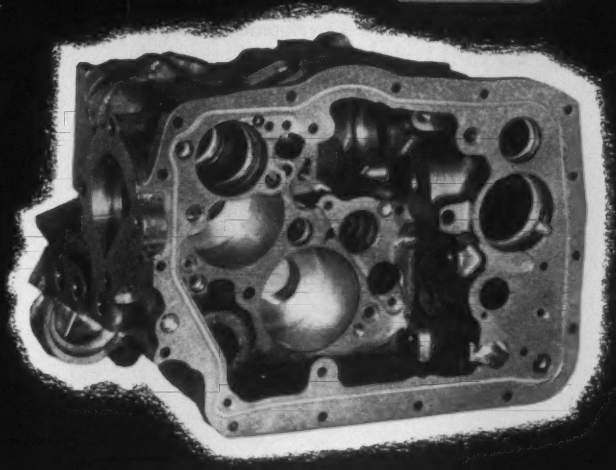
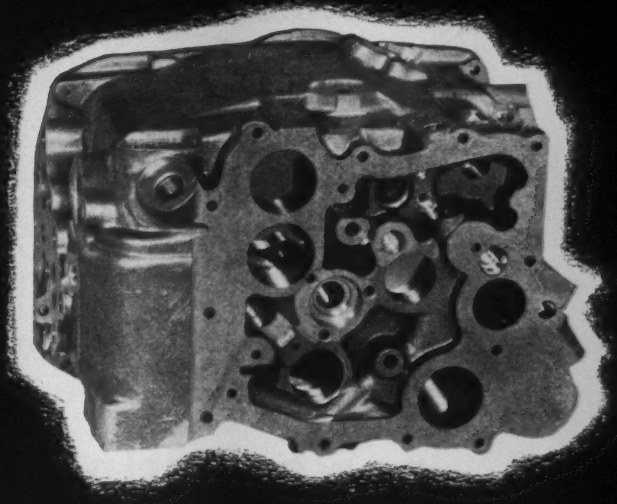
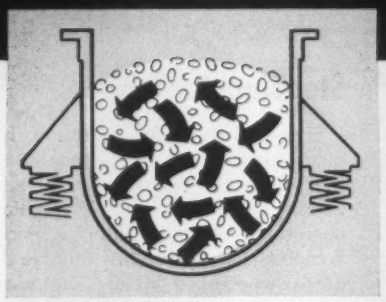
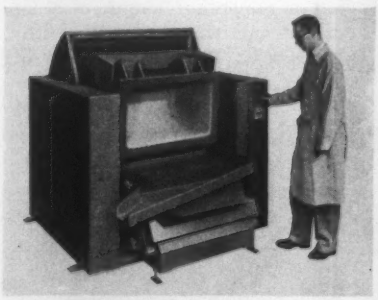






CONSTANT OVERALL ABRASIVE ACTION—The Vibratron work zone extends throughout the abrasive mass. Every surface is subject to constant vibrating abrasive action.



NO MORE MANUAL HANDLING of parts and media. A built-in removable separator does the job. There's no need for an extra separator.

COMPLEX ALUMINUM CASTINGS DEBURRED 2 at a time . . . in 15 minutes . . . . . the **VIBRATRON** way!

Woodward Governor Co., Rockford, Ill., long a leading manufacturer of all types of governors for prime movers, manufacture such highly precise equipment as jet engine fuel control systems. Precise finish and dimensional tolerances are a must! The fuel control shown above was previously hand deburred and then tumbled in a multiple compartment machine for 1 hour. Now . . . these cases are processed *2 at a time in 15 minutes* in the Vibratron. Hand operation is cut by a third, and the finish is more uniform.

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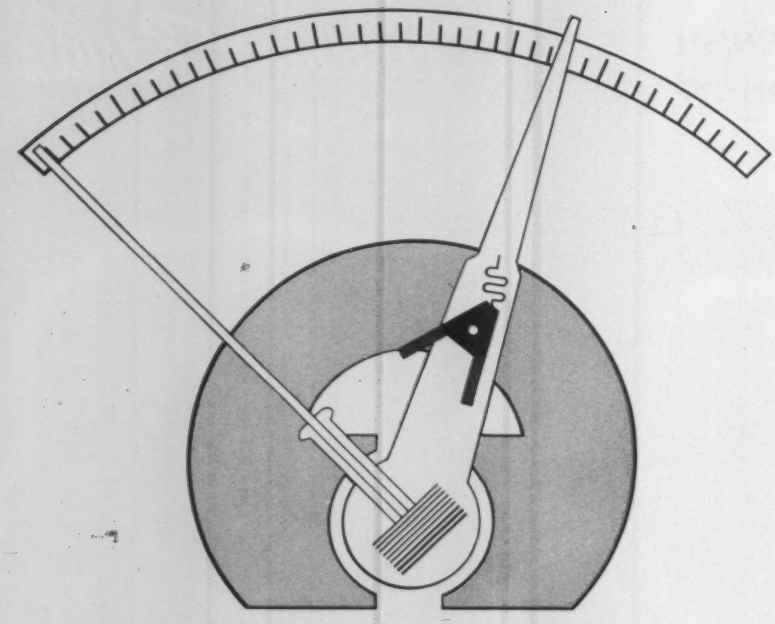

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new CRMR meter-relay offers continuous indication, continuous control utilizing the simplest control system ever

The new CRMR (short for Continuous-Reading Meter-Relay) permits you to perform minor miracles in simplifying control circuitry. A new toggle-contact principle gives full-scale indication at all times with immediate, non-cyclic control response. An unrestrained D'Arsonval movement gives high sensitivity and versatility to measure any electrically-measureable variable.

The entire system consists of the CRMR and a load relay. Interrupters are eliminated. So is their associated circuitry. Reset is instantaneous and automatic.

Because of the exclusive API booster coil, contacting action is fast, firm and virtually without "dead zone." Control performance is uncompromisingly reliable.

THE COMPLETE STORY in pictures . . . a clear, graphic presentation of the CRMR and associated circuitry is provided in Bulletin 5-2.
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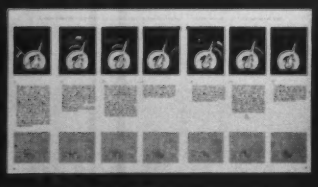

api **ASSEMBLY PRODUCTS, INC.**
Chesterland 27, Ohio

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strument provides a variety of input and output commands, several operating modes, and wide input-output compatibility, so that it can be used in testing many types of digital systems. Model 3-201 generates data words at rates up to 100 kc, and contains separate logic levels for partial word blanking during testing of data storage systems. **Applied Development Corp.**, 12838 Weber Way, Hawthorne, Calif.

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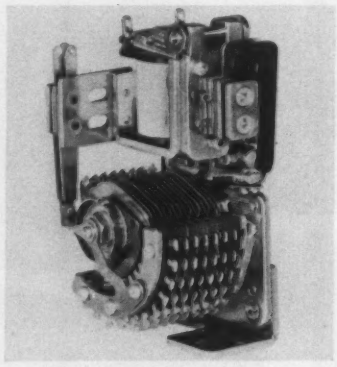

Stepping Switch

Designed for digital operation, 10-point stepping switch is capable of over 100 million operations with twelve 10-point levels; 300 million operations with four 30-point levels. Some of the applications include sequence control, totalizing, sampling, and single point selection. Model 210 transfers from Position 10 to Position 1 without special circuitry. It has a maximum length of 4 5/16 inches and weighs 1½ lb with 12 levels. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill.

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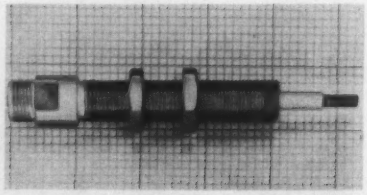

Differential Transformer

Linear variable differential transformer is an ac electro-mechanical transducer used for measurement and control, providing a proportional

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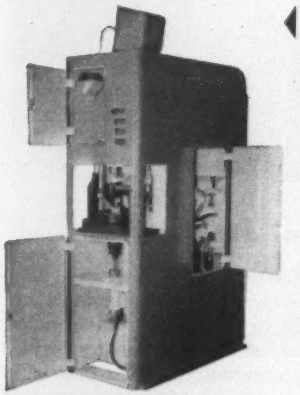
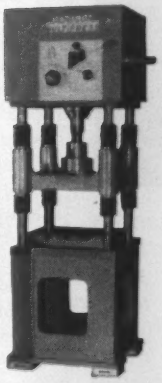
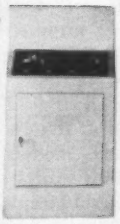


MULTI-COMPACTION PRESS *shown with access doors open. Tooling setup shown is for production of tantalum capacitor anodes. Reel of tantalum wire (seen in upper compartment) is straightened, cut to exact length and fed vertically into the press. Powdered tantalum is automatically fed from overhead hopper into compaction die cavity.*





SERVO-DRIVEN MULTI-PRESS "600" *with movable console which contains operating controls. Note rugged platen and large daylight area. Control lever on upper panel adjusts ram stroke for ¼", ½", ¾", 1", 1½", 2" and 3" work strokes. Feed mechanism is automatically adjusted when operating speed is varied.*

TWO NEW PRESSES fill the long-standing need for a high speed hydraulic progressive stamping press and a productive, dependable powdered materials compaction press. Here are some of the key features of these advanced new units:

High Speed Servo-driven Multipress "600"

- 600 strokes per minute with 25-ton capacity.
- Strokes per minute and ram pressures are adjustable while press is operating.
- Simple lever adjustment of ram stroke length. Cams can be easily changed for special work strokes.
- Harmonic cam drive automatically sequences the feed mechanism for perfect cycling with ram operation.
- Punch breakthrough is adjustable . . . does not rely on mechanical stops.
- Press frame and power unit are shock-mounted . . . resulting in minimum operating noise level.

Multi-Compaction Press

- Designed for volume production of ferrous, non-ferrous and exotic metals . . . glass and plastics.
- Fully automatic, unattended operation.
- Enclosed tooling area eliminates spillage and loss of material.
- Single or automatic cycle operation . . . all-hydraulic control.
- Self-contained, overhead stainless steel hopper feed.

Your nearby Denison hydraulic press specialist can show you how the new Multipress "600" and the Multi-Compaction press can help make your products better for less. Call, write or wire for details.

DENISON ENGINEERING DIVISION
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These two new presses will be demonstrated at the Machine Tool Exposition in Chicago, September 6-16.

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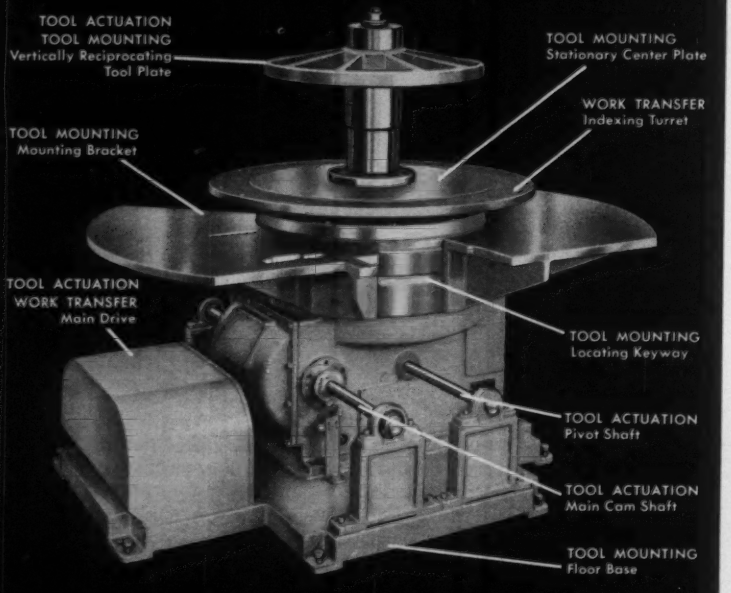

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Circle 715 on Page 19

ac output in sensing linear displacement. Model H101A, with an excitation voltage of 10v rms and a carrier frequency in the range 400 cps to 3 kc, will operate consistently from −65 F to +250 F, even under rapid environmental changes. In a linear range of one to 4 inches, the transducer has a non-linearity of 0.5 per cent or less. Unit is available in three sizes. Sensitivities in millivolts output per input volt per 0.001 inch are 1.0 for the smaller model to 0.25 for the largest when operated from a 1 kc carrier. Resolution is continuous, and repeatability is 0.01 per cent or better. **Pacific ElectroKinetics**, 329 South Vermont Ave., P. O. Box 728, Glendora, Calif.

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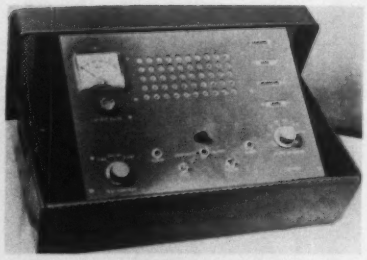

Circuit Tester

Device designed for testing cable, assemblies, and components is applicable in electronics, instrument, and industrial operations. Feature of the automatic circuit tester is its speed; it will test 60 circuits in one minute. The unit tests the desired circuits and displays the results by means of numbered indicator display lights. Faulty circuits are indicated by red lights. The lights remain red until the *Clear* button is depressed at the end of the test. Three standard models are available—a 50-circuit unit, a 100-circuit unit, and a 200-circuit unit. The circuit tester can be used on a test bench, and when front mounted on a standard rack provides a console type test station. The hi-pot voltage is variable up to 300 v dc. The continuity current is 5 ma, 500 ma, and 1 and 2 amps. The unit also contains a pre-set timer for regulating the dwell time per circuit. **Astral Electronics Inc.**, 14620 Arminta St., Van Nuys, Calif.

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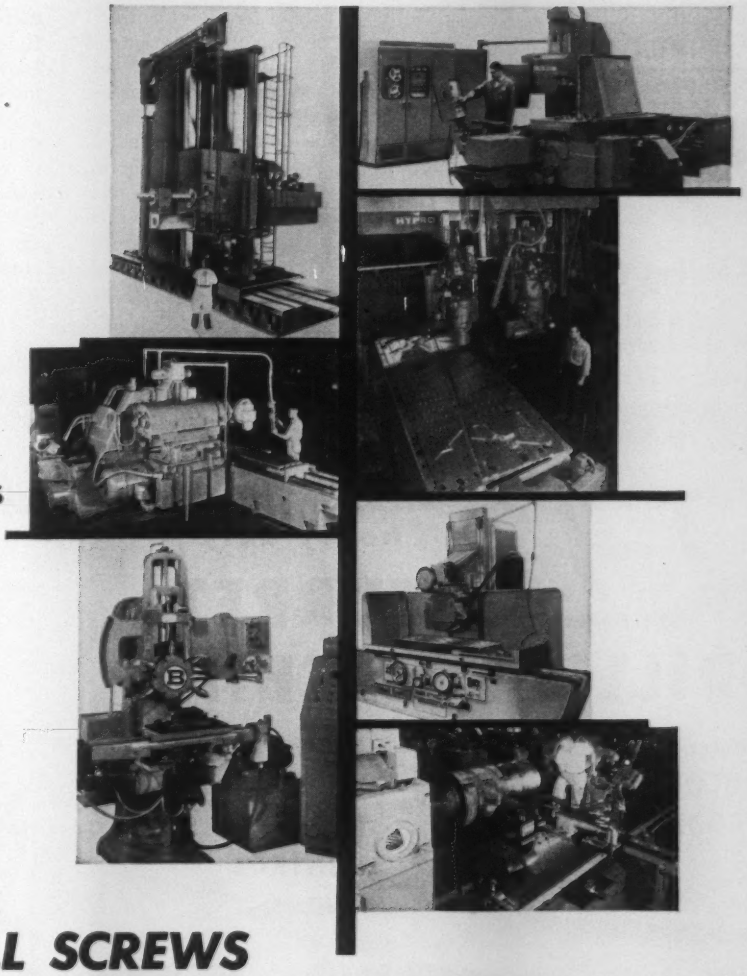
Without a doubt there will be more **Beaver** ball screws than any other make on machine tools being demonstrated at the M.T.B.A. show in Chicago next month

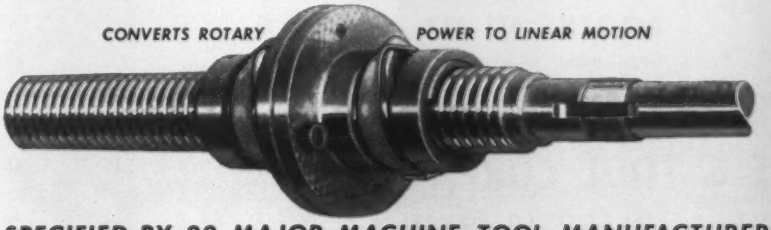


BEAVER BALL SCREWS

Part of the Secret of Their High Precision!

Tolerances close as .001″ maximum error in 10 feet of ball nut travel are not uncommon in Beaver Ball Screws. Spring rates in excess of 20 million pounds per inch are not exceptional. They're specified where system stiffness that permits accurate locating and repeatability, free from backlash and surge, is essential. 90% (plus) efficiency with consequent low power requirements, compactness and reliability are inherent Beaver characteristics. That's why they are used in actuating vital aircraft parts and head slides and tables of precision machine tools as well as critical functions in other capital equipment.

Beaver Ball Screws provide for the moving of massive loads or extreme small parts such as fuel metering devices with equal sensitivity. Our engineers will be glad to consult with you in determining where they may serve better than hydraulic, pneumatic or acme screw actuation in your product. Write for our catalog.

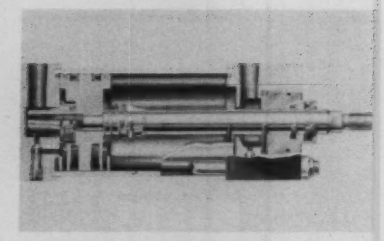


SPECIFIED BY 22 MAJOR MACHINE TOOL MANUFACTURERS

Largest manufacturers of precision ball screws

Beaver Precision Products INC.

CLAWSON, MICH.



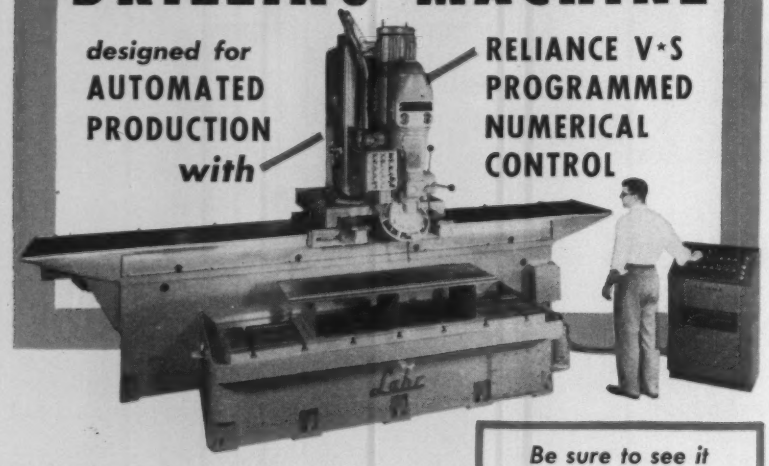
Double-Acting Cylinder

Line of square end double-acting pneumatic and hydraulic cylinders features a special two-stage cushion to assure smooth deceleration of piston. This cushion is fully adjustable by means of a needle valve. Working media and maximum pressures for the cylinders are as follows: Air to 250 psi for all bores; oil to 1000 psi through 3¼-inch bore, oil to 700 psi through 5-inch bore, and oil to 600 psi on the 6-inch bore; cylinders for use with water are supplied on special order. Bore sizes range from 1½ to 6 inches and several choices of rod diameters are available for each size. Range of temperatures varies as follows for the different media: Air models to 212 F; oil models to 250 F; cylinders may be ordered to withstand 400 F on special order. Leather piston wipers which act as oil reservoirs are supplied on all pneumatic models. Other features of the cylinders include: High tensile chrome plated steel piston rods; rod bearing cartridge accurately machined and made of bearing bronze; and seamless, hard drawn, microinch finished brass barrels. **Mead Specialties Co.**, Dept. SH-46, 4114 North Knox Ave., Chicago 41, Ill.

Circle 440 on Page 19

Lahr *heavy-duty* TURRET DRILLING MACHINE

designed for AUTOMATED PRODUCTION *with* RELIANCE V•S PROGRAMMED NUMERICAL CONTROL



The stationary work table permits loading of large pieces or parts, especially long and narrow work, and accurate drilling operations completed without a change in setup. Also, it is possible to position a number of small parts to run consecutively without change. The spindle covers the entire area of the work table.

The many features of design and operation will contribute greatly to increased productivity and better quality, as well as to reduced costs.

Lahr engineers are specialists in numerical control drilling machine designing and manufacturing.

Be sure to see it at the

PRODUCTION ENGINEERING SHOW

Chicago Navy Pier

RELIANCE ELECTRIC & ENGINEERING CO.

BOOTHS 411-417

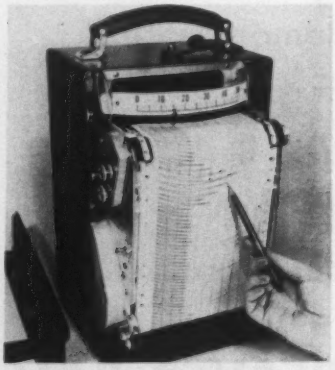
September 6-16, 1960

or write for literature

Lahr MACHINE & TOOL CORP.

3400 MAPLEWOOD AVENUE • TOLEDO 10, OHIO

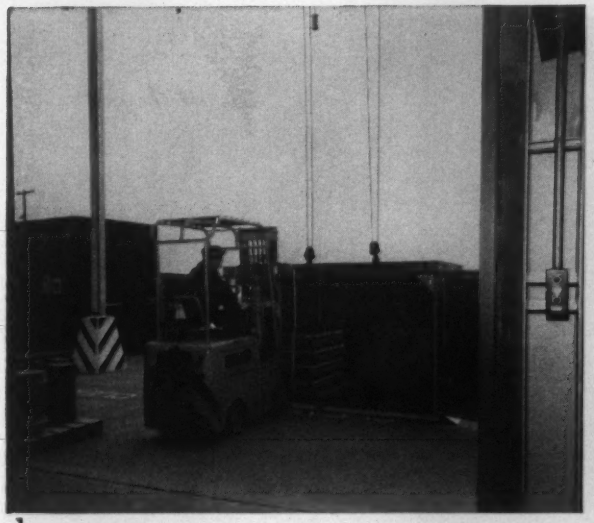
Circle 717 on Page 19



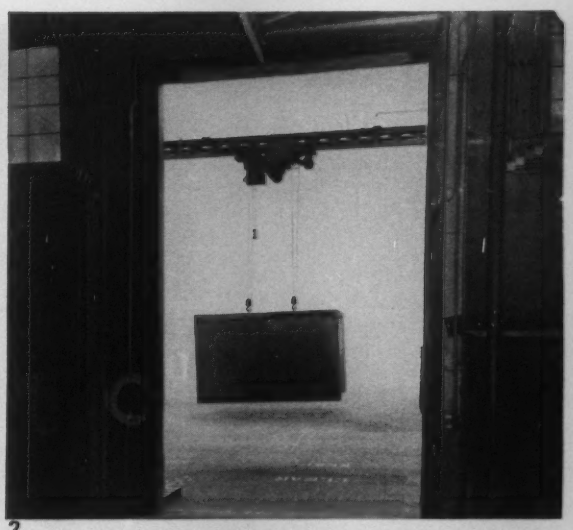
Time-Speed Recorder

Graphic recording instrument helps spot hidden trouble in machine operations and processes by timing short duration events to millisecond accuracy, even at slow chart speeds. It provides accurate operation timing along with time-of-day information. Time recorder operates on 115 v, 60 cycles. Standard chart speeds of ¾, 1½, 3, 6, and 12 inches per hour, and per minute, are provided. Time markings along edge of the chart show time of day any event occurs while sweep of the recording pen across the chart displays duration of the event. Timing is accomplished by closing or opening an electrical control circuit. A chronograph pen also can be added to permit simultaneous recordings of the time other related events occur. **R. B. Annis Co.**, 1101 N. Delaware St., Indianapolis 2, Ind.

Circle 441 on Page 19

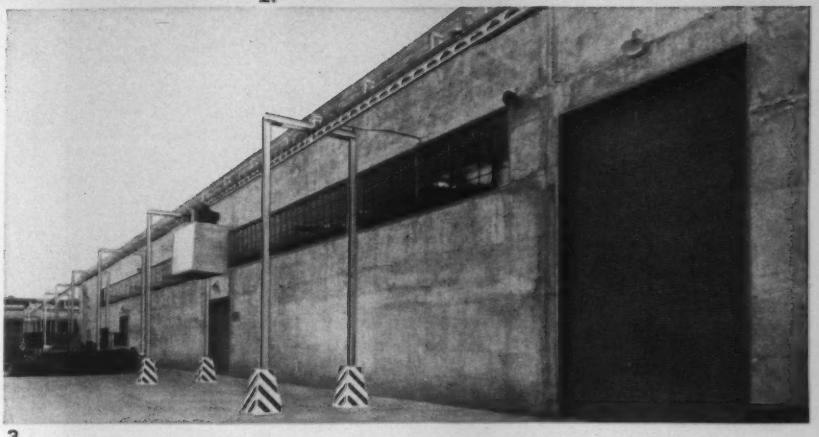


1.



2.

1. Loading carrier van with power truck.
2. Up she goes. Depressing wall button sends carrier on its way.
3. En route to another building.



3.

Robot Carrier Delivers Materials Automatically

WITH a Cleveland Tramrail Robot Carrier, it is no problem to move materials between buildings. Heavy loads can be dispatched great distances without operators, safely, at low cost. The equipment opens and closes doors, if necessary, and stops automatically upon reaching the selected delivery point.

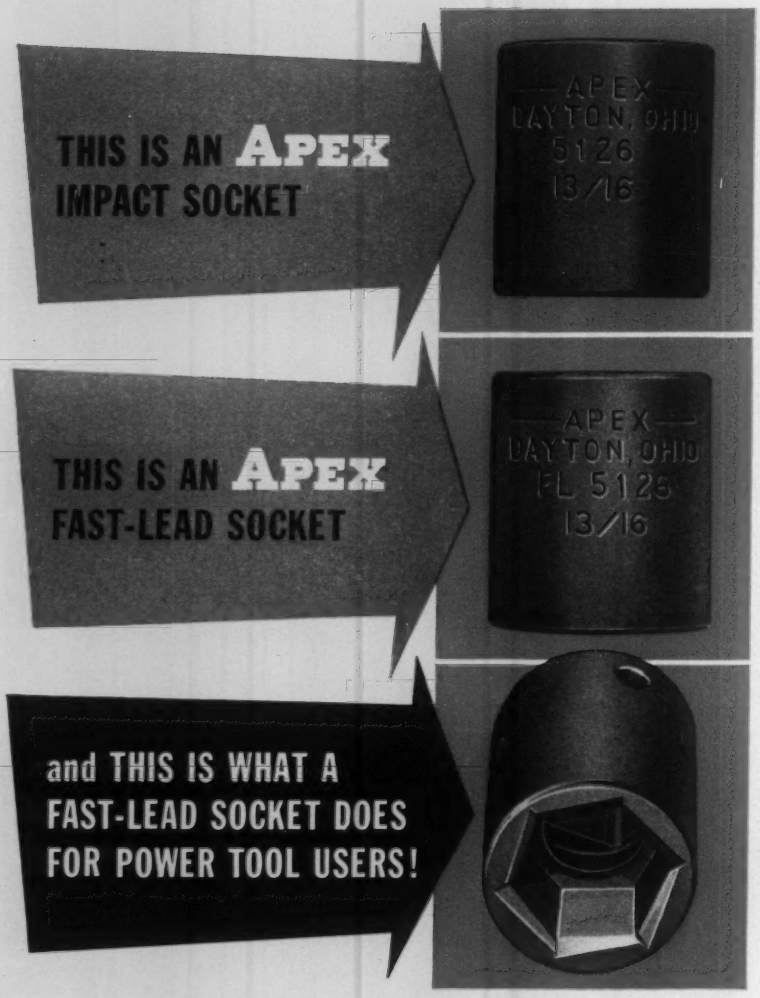
Cleveland Tramrail has developed a wide variety of automatic materials handling equipment which is now in service providing tremendous savings.

GET THIS SPECIAL REPORT
Write us for your free copy of "AUTOMATIC DISPATCH PORTFOLIO" Gives data on a variety of cost-reducing automatic handling installations.

CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
1309 East 290th Street, Wickliffe, Ohio

CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

Circle 718 on Page 19



The broached opening on an Apex Fast-Lead Socket is designed to lead the socket on to the nut or bolt, engaging completely the instant contact is made.

When you use Apex Fast-Lead Sockets on power tool production operations, you can run down an entire series of nuts or bolts without ever stopping the tool. Because an Apex Fast-Lead Socket "gets on" in one-sixth of a turn, with a single, uninterrupted motion, it isn't necessary to even hesitate just before the socket makes contact. And that goes for multiple power tool units, too.

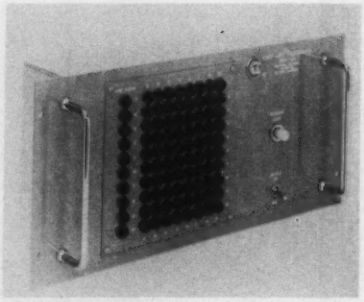
Apex Fast-Lead Sockets . . . ¼" through ⅝" square drive . . . ⅜" through 1 1/16" broached hex openings . . . short, standard, long and extra long lengths. Catalog 30-A has all the facts—write, on your company letterhead please, for your copy.

APEX FASTENING TOOLS

SCREWDRIVING • NUT RUNNING • SPECIAL

The APEX Machine & Tool Co. • 1035 So. Patterson Blvd. • Dayton 2, Ohio

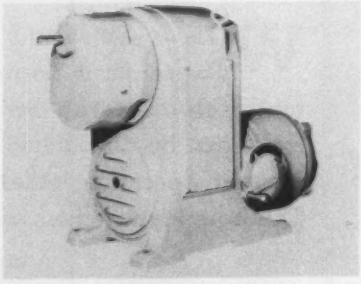
Circle 719 on Page 19



Tape Programmer

Feature of Model 213 is its ability to program tape at one setting for an entire ten line, eight-hole set of frames. It is designed for use with company's tape-programmed testers. Frames can be altered or added while duplicating tapes. The programmer can also punch tape frame by frame as well as line by line. Programmer, designated Tape-Ard, has ten eight-position, spst, accumulative switches. A *Clear* button for each individual eight-position switch is provided as well as a master *Clear* button for all ten switches. Two six-foot cables are provided to be used with the two cables of the Tape-Ard reader when the two units are used in conjunction with each other. **California Technical Industries, Div., Textron Inc.**, 1421 Old County Rd., Belmont, Calif.

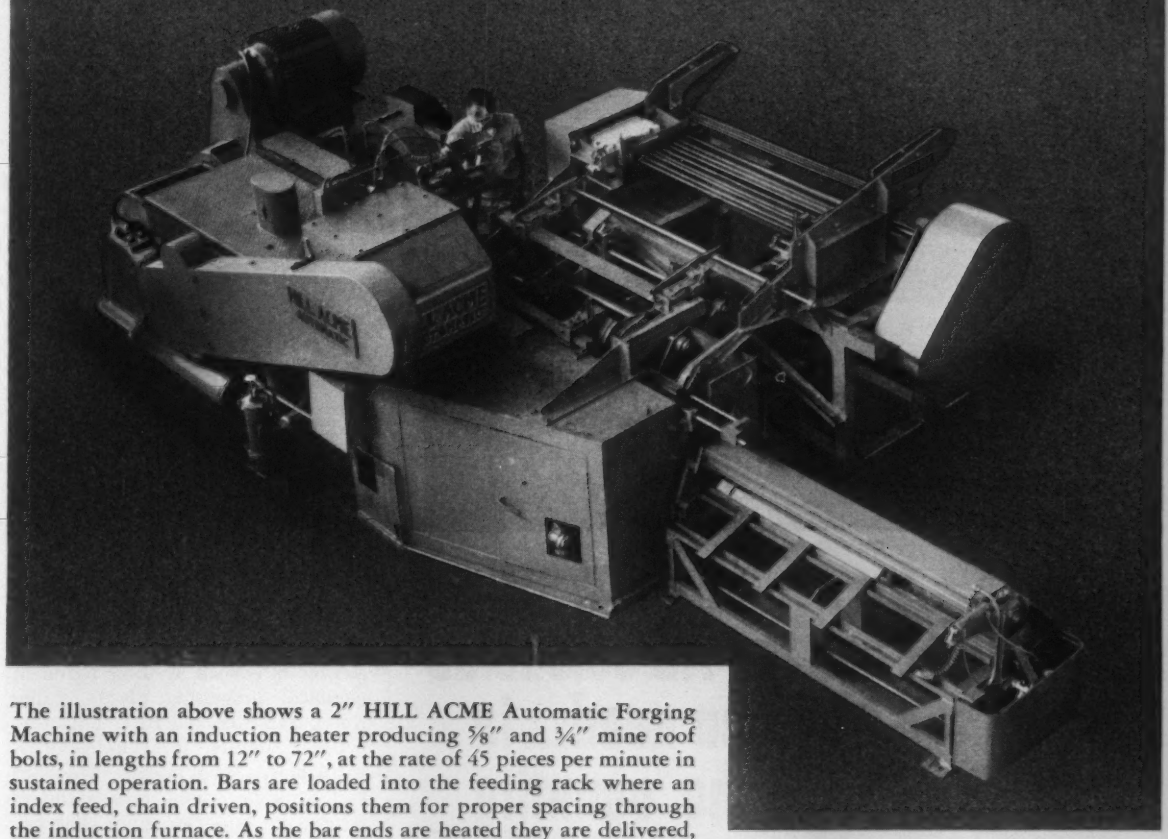
Circle 442 on Page 19



Variable Speed Drive

Variable speed drive designated Model VEU-GHY will operate at speeds from 2500 to 25,000 rpm. It is adaptable for use in high-speed emulsification, seal testing, generator testing, high-speed hydraulic pumps, centrifuge applications, polishing, static balancing, and ultra high-

Fully Automatic
FORGING MACHINE
DELIVERS 45 PIECES PER MINUTE!



The illustration above shows a 2" HILL ACME Automatic Forging Machine with an induction heater producing 5/8" and 3/4" mine roof bolts, in lengths from 12" to 72", at the rate of 45 pieces per minute in sustained operation. Bars are loaded into the feeding rack where an index feed, chain driven, positions them for proper spacing through the induction furnace. As the bar ends are heated they are delivered, at the proper timing cycle, to the forging machine by a roller chain feed where they are gauged for length, picked up by fingers and passed progressively through the dies. Finished forgings are discharged from the back of the machine by means of a separately driven conveyor, arranged for both right and left hand discharge.

The design of this new HILL ACME AUTOMATIC forging unit does not limit the number of passes or the length of stock to be used in forging a variety of parts. Pieces longer than 36" are supported by a walking beam through the various passes.

HILL ACME AUTOMATIC forging machines are built in 1¼" to 5" capacities all of which can be automated. Your inquiry concerning high speed automatic forging equipment will receive prompt attention.

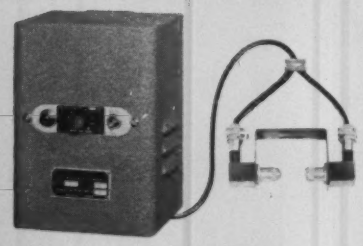
MMT=PE

The HILL ACME Company

1207 W. 65th STREET • CLEVELAND 2, OHIO

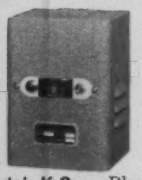
Manufacturers of: "ACME" FORGING • TAPPING MACHINES • "CANTON" ALLIGATOR SHEARS • ROTARY SHEARS • BAR-BILLET SHEARS • "HILL" GRINDING AND POLISHING MACHINES • HYDRAULIC SURFACE GRINDERS • "CLEVELAND" KNIVES • SHEAR BLADES • MATERIAL HANDLING EQUIPMENT

Circle 720 on Page 19

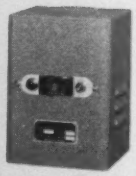


POST ELECTRONIC PRODUCTS

Model K-1A — When the light beam is not interrupted — output relay is energized.
Model K-1B — When the light beam is interrrupted — output relay is energized.



Model K-2 — Photo-electric timer with adjustable (.05-10 sec.) output relay closure.



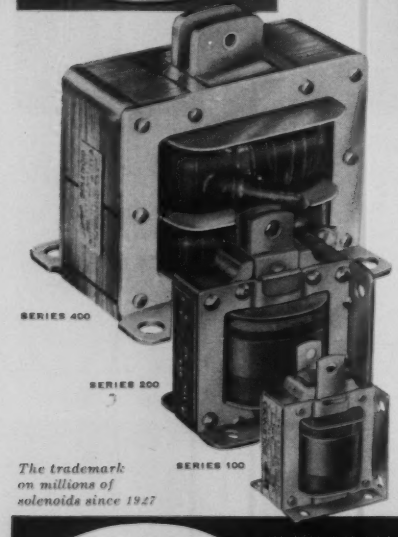
Model K-3 — Photo-electric stop-motion and jam detector:
K-3R — When light beam is interrupted for the present time delay-output relay is energized.
K-3F — When light beam interruptions cease for a preset time delay-output relay is energized.

Decitron

POST ELECTRONIC PRODUCTS
Division of Reid Brothers Company, Inc.
12 LOTHROP ST. / BEVERLY, MASS.

Circle 721 on Page 19

WesCo has the AC solenoids you need... in the quantity you need!



The trademark on millions of solenoids since 1927

WESCO's famous Series 100, 200 and 400 AC solenoids — 75 models in all — are immediately available in small or large quantities! One of these designs may fit your requirements. If not, WESCO engineers will design a special solenoid for your application. Inquire now.

WesCo designs and manufactures aircraft solenoids for military and commercial application. Write for complete catalog.

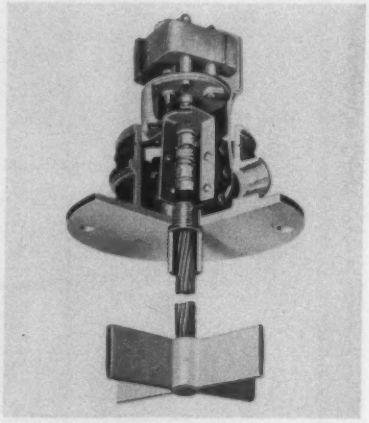
WesCo WEST COAST ELECTRICAL MFG. CORP.

233 W. 116TH PLACE • DIVISION 122 • LOS ANGELES 61, CALIFORNIA • PLymouth 5-1138

Circle 722 on Page 19

speed agitation. Unit consists of an electric motor and variable speed transmission with a gear increaser called Syncrogear. The entire unit stands less than 2 feet high. The gears are honed for precise profile and super finish. To prevent over-lubrication a metered lubrication system is used. **U. S. Electrical Motors Inc.**, Box 2058 Terminal Annex, Los Angeles 54, Calif.

Circle 442 on Page 19

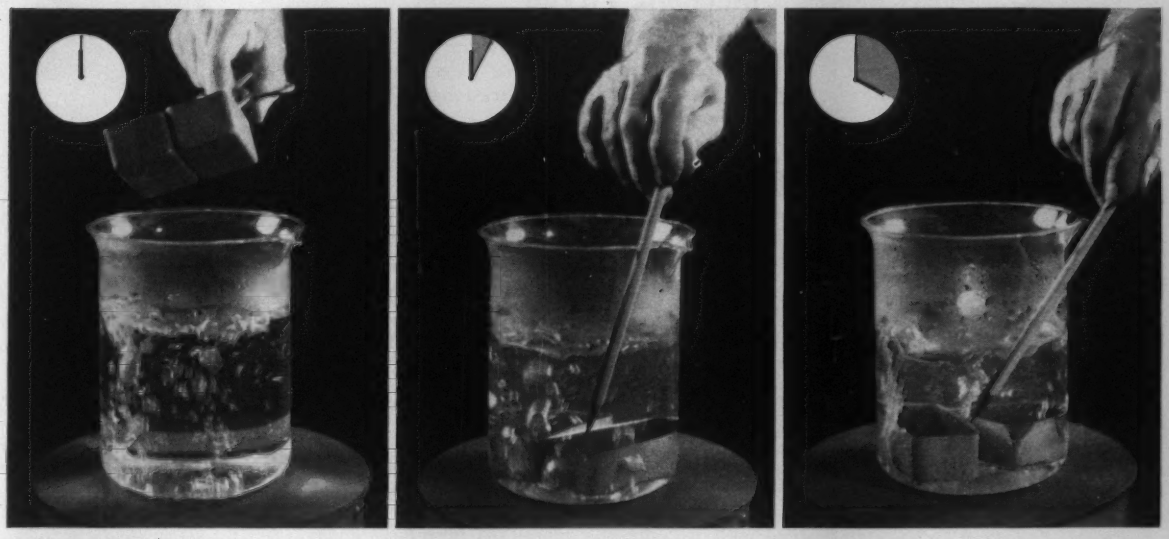


Level Indicator

Designated Flexi-Shaft, unit has been designed for use in large bulk storage bins such as those found in chemical processing plants, paper mills, and steel plants. This top-center mounted level indicator is available in two models: Standard and explosion proof. The standard is used for bulk storage of all types. In operation, the indicator's 1/100 hp motor turns a 4-blade paddle by means of a torsion spring. The paddle turns continuously as long as no material touches it. Feature of the device is its ability to assure control at any level. If material makes contact with the paddle, it stops. However, the motor continues to run, expanding the spring until it actuates a limit switch. This switch turns off the motor and any other equipment controlled by the indicator. When the material falls away from the paddle, the torsion spring reactivates the paddle and unwinds from the limit switch, starting the motor and putting the unit in operation again. **Convair**, Pittsburgh 26, Pa.

Circle 444 on Page 19

A DRAMATIC DEMONSTRATION OF THE NEW CLAD-REX 102 LAMINATE



Boiling water provides a positive test for two deep drawn* vinyl-clad parts. Neither special care in forming, nor post curing has been used to prepare either part.

Almost within a matter of seconds, the part formed of conventional vinyl-clad metal (at right) begins delaminating at the corners.

Even after as long as four hours of boiling, the part formed of new Clad-Rex 102 laminate (at left) still shows no delamination whatsoever.

New Clad-Rex vinyl-clad metal sharply reduces limitations in deep drawing and heat exposure

Has your interest in vinyl-clad metals been cooled because your product is deep drawn? . . . or because your product is exposed to elevated temperatures? . . .

Now, you can solve the problem with new Clad-Rex 102. It's a new vinyl-metal laminate that is, in effect, a single element of material. Clad-Rex 102 combines *for the first time* the ultimate properties of sheet metal with the optimum characteristics of vinyl.

Call or write for facts of this major technological breakthrough by the extensive research laboratories of Simoniz Company.

*Depth of draw equal to six times radius of corner

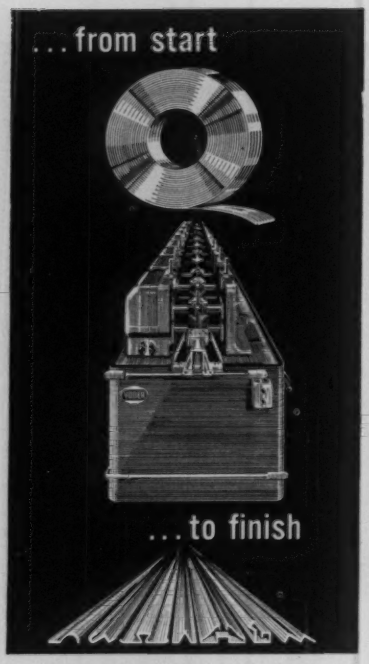
VINYL-METAL LAMINATES BY **CLAD-REX**® DIVISION OF SIMONIZ COMPANY

11508 W. King Street • Franklin Park, Illinois

Telephone: GLadstone 1-2323

22C

Circle 723 on Page 19



YODER ROLL-FORMING EQUIPMENT

Profits are available to you through the production of many shapes in metal... made with precision and economy on Yoder Cold Roll Forming Equipment.

Produce tubular, ornamental or structural shapes from a variety of metals in widths from a fraction of an inch up to 80 inches or more, and in stock up to ¾" thick. Your investment is comparatively modest, and with proven low operating costs, will give you one of the most profitable operations in your plant.

Experienced Yoder engineers will, without obligation, study your annual metal forming requirements. Many times they can point out that the installation of roll forming equipment would—even if operated only intermittently—soon justify its initial cost.

Send today for this comprehensive, 88-page illustrated text. It fully describes Cold Roll Forming Equipment, processes and products.

THE YODER COMPANY
5526 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING COLD ROLL FORMING MACHINES

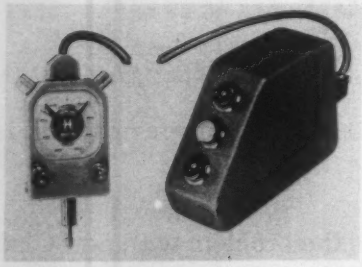
Circle 724 on Page 19

Magnetic Pickup

Magnetic pickup capable of operating at temperatures as high as 800 F is suitable for industrial measurement and control applications. Unit designated the Series 3100 is

wound with a special copper and nickel magnet wire, and insulated with a ceramic material to permit operation at high temperatures. The pickup is mounted in an internally threaded hole. Connections to the unit can be made by means of silver brazing to lugs or by means of a special 1000 F mating connector. **Electro Products Laboratories Inc.**, 4500 N. Ravenswood Ave., Chicago 40, Ill.

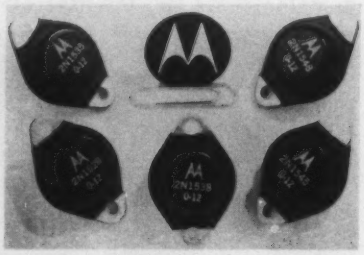
Circle 445 on Page 19



Electric Indicator

Instrument, which signals tolerance conditions, can be used for automatic control or to turn on lights. In operation, an electric signal is generated whenever established tolerance limits are exceeded. By the addition of an adapter, the light box can be converted to a summarizing box for up to six electric indicators when gaging multiple dimensions. With this arrangement, an out of tolerance condition will be signaled by the OVER and/or UNDER light. If all dimensions are within tolerance, the GOOD light will signal. **Hamilton Watch Co.**, Lancaster, Pa.

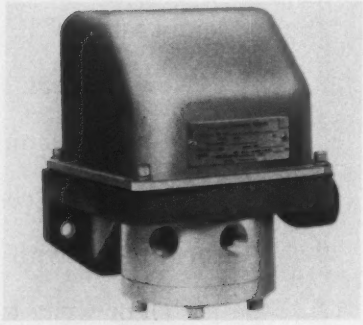
Circle 446 on Page 19



Power Transistors

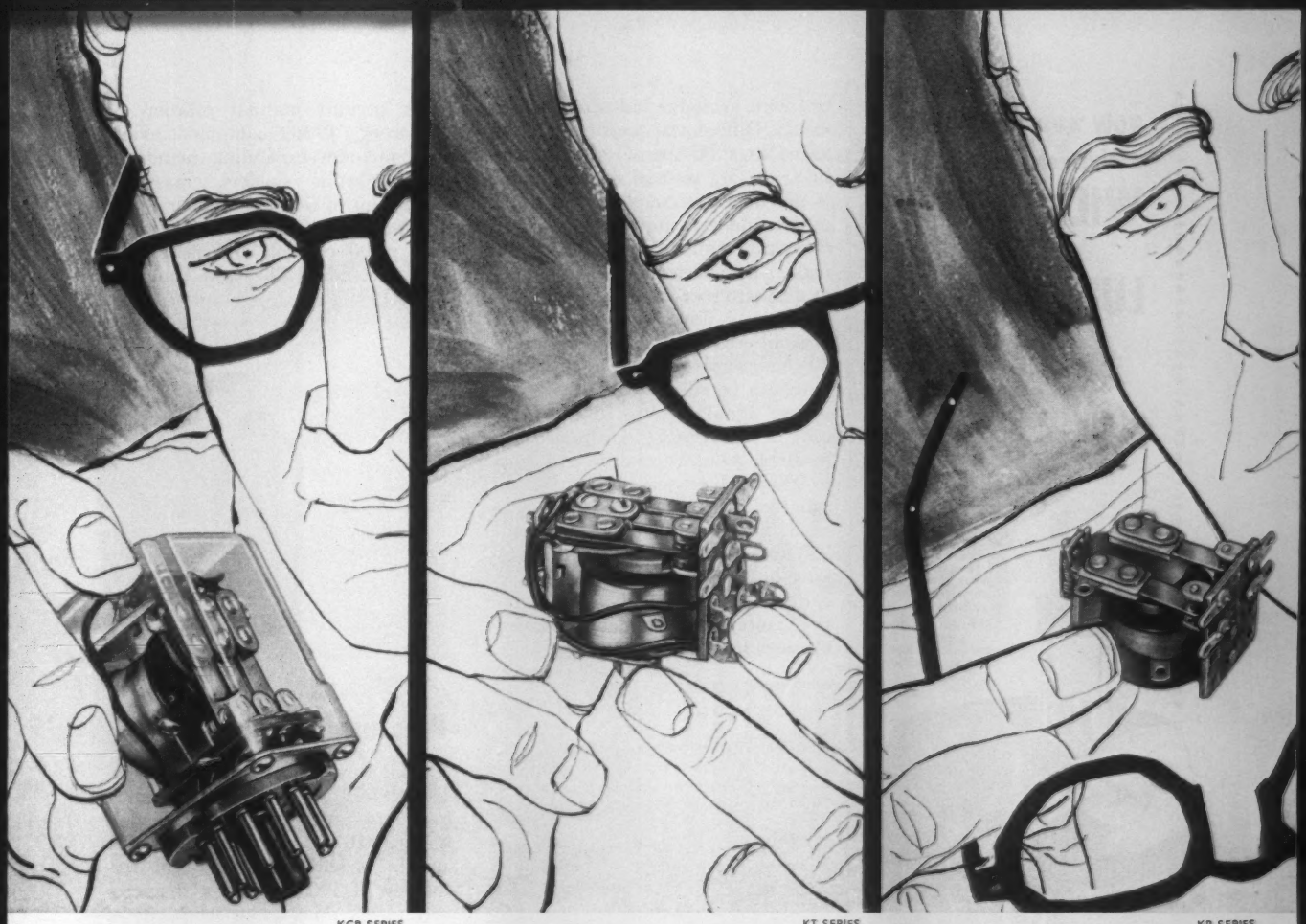
Line of 5-ampere industrial power transistors featuring 2 to 1 beta spreads is suitable for industrial switching control and amplifier applications from dc through the audio frequency range. Collector-base breakdown voltages from 40 to 120 v and measured current gains from 20 to 150 allow operation of these transistors as switches at power levels up to 500 watts. Transconductance as high as 10 ohms and a saturation resistance as low as 0.03 ohm make the devices suitable for converter applications. Models 2N1529 through 2N1538 (medium gain) and 2N1539 through 2N1548 (high gain) are germanium PNP, alloy junction power transistors with collector common to case. **Semiconductor Products Div., Motorola Inc.**, 5005 East McDowell Rd., Phoenix, Ariz.

Circle 447 on Page 19



Pressure Transmitter

Instrument is designed for flow and differential pressure measurement and transmission. Unit measures the difference in pressures between two points in a fluid system and transmits the information as an electrical output which can be used directly for indication and/or con-



KCP SERIES KT SERIES KR SERIES

three for dependability at low cost

MEET P&B's FAMILY OF "K SERIES" RELAYS

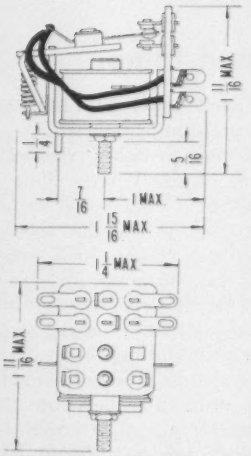
Here are only three of a large family of "K Series" relays by P&B. Blood brothers all, they are distinguished by fine craftsmanship and design maturity. Together they will handle a multitude of switching requirements.

Many design engineers find it saves time, saves money to integrate their circuits with *related* P&B relays. Makes sense, doesn't it?

KR—A small, lightweight relay used widely in communications and automation. Engineered for long life and dependability. 3PDT max. AC or DC. (See engineering data.)

KT—Designed for antenna switching. Capacitance: 0.5 mmfds between contacts. Terminal board is glass melamine and stack insulation is glass silicone for minimum RF losses to switch 300 ohm antenna line. 3 PDT max. AC or DC.

KC—Low cost plate circuit relay with sensitivity of 125 mw per pole. Factory adjusted to pull-in on specific current values. Available open, hermetically sealed or in clear plastic dust cover with standard octal-type plug. 3 PDT max. DC.



KR ENGINEERING DATA

GENERAL:
Breakdown Voltage: 500 volts rms minimum between all elements.

Temperature Range:
DC Coils—45°C to 85°C.
AC Coils—45°C to 70°C.

Terminals:
Pierced solder lugs standard. Octal 8 and 11 pin plug-in headers available.

Enclosures: Type K—Hermetically sealed.
Type P clear cellulose acetate dust cover.

CONTACTS:
Arrangements: 3 Form C (3PDT) max.
Material: 1/8" dia. fine silver (gold plated).
Other materials available to increase contact capacity.
Load: 5 amperes 115V 60 cycle resistive.

COILS:
Resistance: 16,500 ohms max. AC or DC.

Power: 1.1 watts minimum to 4 watts maximum for DC at 25°C ambient.

Duty: Continuous.
Insulation: Centrifically impregnated with insulating varnish.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

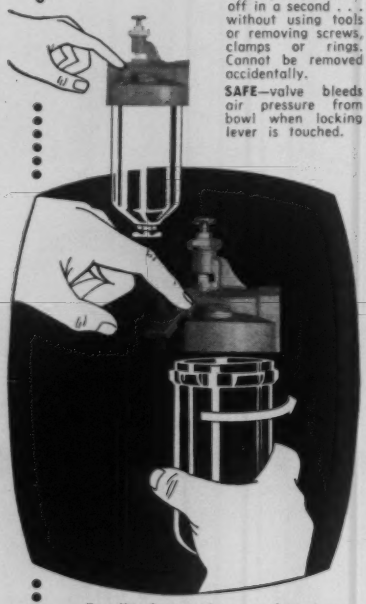
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

Circle 725 on Page 19

NOW AVAILABLE
exclusively on the
WILKERSON
#3014
LUBRICATOR
NEW KWIK-CHANGE BOWL

Simply touch the quick-release locking lever, turn bowl slightly and bowl is off in a second . . . without using tools or removing screws, clamps or rings. Cannot be removed accidentally.

SAFE—valve bleeds air pressure from bowl when locking lever is touched.



Profit from these advantages of a Wilkerson 3014 Lubricator

* 1 to 300 CFM
* Site-Flo gauge
* Two fill holes
* Fill while air pressure is on
* Bowl can be removed without turning off air

PLUS

The time-saving advantages of the Wilkerson

KWIK-CHANGE BOWL

Note: 3014 lubricator can be equipped with the Wilkerson auto-fill mechanism to maintain lubricant at safe level.

Get complete information on the versatility and cost-saving advantages of the new 3014 series.

Write for circular #1028.

WILKERSON CORPORATION

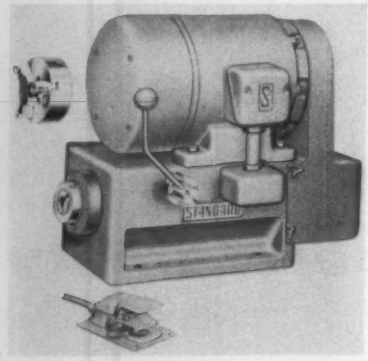
Dedicated to keeping the NEW in pNEUmatics

1552 W. Girard • Englewood, Colo.

Circle 726 on Page 19

trol with available industrial instruments. Differential pressures are detected in a Ni-Span-C sensing capsule. A slug secured to the capsule is magnetically coupled to a linear differential transformer. Use of an electrical symmetry sensing circuit makes the detector readily adaptable to a square root extraction for direct readings of flow. The device measures differential pressures from 0 to 80 inches of water directly. The span can be adjusted to provide full output signal over the upper 30 per cent of this range. Units are also available to measure differentials up to 220 psi. Electrical output over the range of differential pressures varies from 0 to 1 milliampere dc into a 750 ohm load. A self-contained regulator and demodulator maintain linearity despite variations in excitation voltage. **Consolidated Controls Corporation**, Bethel, Conn.

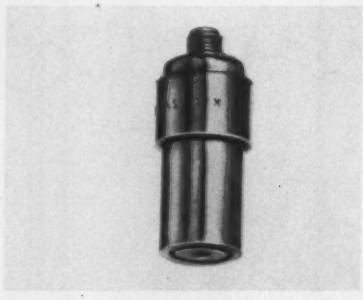
Circle 448 on Page 19



Speed Lathe

Bench model speed lathe is capable of polishing, burnishing, lapping, spinning, reaming, deburring, and filing of small parts. The versatile feature of this speed lathe is the variation in spindle speeds, ranging from 180 to 3600 rpm. Selection can be made for one-speed or a wide range of two or four-speed combinations. There is a 1-inch diameter through-hole in the shaft. The spindle nose accommodates No. 5C draw-in collets up to 1-inch diameter round, $\frac{7}{8}$-inch hex, and $\frac{3}{4}$-inch square. Hand lever control delivers simultaneous opening/closing of the collet, closing/opening of the motor circuit, with instant applying/releasing of the brake. Partial travel of the hand lever permits manual rotation of the work. Other equipment available includes expanding mandrels, special work holders, magnetic chuck, up to 6-inch diameter 3-jaw lathe chuck, air collet or air chuck, foot pedal control, and floor pedestal. **Standard Electrical Tool Co.**, 2550 River Rd., Cincinnati 4, Ohio.

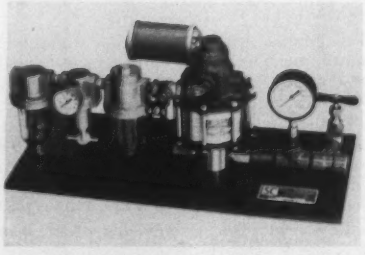
Circle 449 on Page 19



Pressure Pickup

Unit can measure pressure variations of 0.1 psi throughout a rated range of 5000 psi. Special models cover a 10,000 psi range. The 701 quartz pickup has a natural frequency of 100,000 cps, a 5 microsecond rise time, and a sensitivity of 200 mv/psi when used with a one foot cable. It contains semicylindrical, natural quartz crystal transducer elements mounted in a rigid-column arrangement to directly resist pressure or force. The normal temperature range of the unit is from −400 F to +500 F. **Kistler Instrument Corp.**, 15 Webster St., North Tonawanda, N. Y.

Circle 450 on Page 19



Power Unit

Air-operated hydraulic power unit is designed for oil and water service in operating hydraulic equip-

FOR EXTRA LOAD CAPACITY IN MINIMUM RADIAL SPACE use

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GUIDEROL® BEARINGS

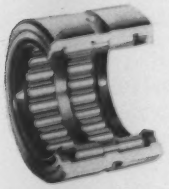
MT SERIES

Here is a compact bearing with high load-carrying capacity. Its full complement of race-width rollers is guided by an integral rail in the outer race bore, providing strength and skewing limitation that prevents binding under controlled misalignment. Rollers are guided at any operational angle from horizontal to vertical — self-cleaning through open ends. Available with or without separate inner ring in shaft sizes from ½" to 9¼". Dimensionally interchangeable with ordinary heavy duty needle bearings.

CT SERIES

Offer full type roller bearing capacity dimensionally interchangeable with ball and cylinder roller bearings of single and double row dimensions. The inner ring may be eliminated for further reduction of radial space.

SEALED—AND STILL COMPACT



No extra axial space needed for the sealed SG series GUIDEROL bearing. Seals are press-fitted securely in the outer race bore to provide the same width and performance advantages of standard GUIDEROL bearings. Contaminants are locked out, lubricants sealed in for those hard to re-lubricate applications. The SG series solves the problem of too-expensive auxiliary sealing assemblies.

Write for McGill's Bearing Catalog #52-A, for engineering data with dimensional and capacity information on McGill needle type roller bearings. Ask about special precision ball and roller bearings.

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precision needle roller bearings

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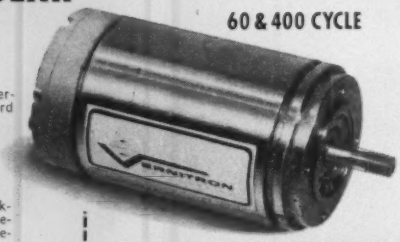

ALL SIZES—11 through 23
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Circle 728 on Page 19

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Twenty-Station, Ten-Unit Transfer Machine for boring, counterboring, chamfering and valve clearance operations on V-8 automotive engine blocks. (Shown)

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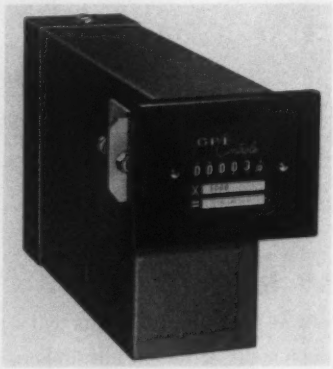
Circle 729 on Page 19

ment and in static and burst pressure testing. It is available in two complete series, SC 40-500 with 10 models from 500 to 25,000 psi hydraulic pressure and SC 40-600 with eight models from 1000 to 30,000 psi hydraulic pressure. They provide a wide range of operating pressures and capacities, from 3 gpm at 500 psi to 20 cubic inches per minute at 30,000 psi. All models are easy to install with only three connections required: To air, fluid supply, and to the work. Two pressure ports, one equipped with valve, provide ease of control during operation. Air piston actuating valve is automatically positioned on the power stroke with each cycle of operation. **SC Hydraulic Engineering Corp.**, 14032 S. Avalon Blvd., Los Angeles 61, Calif.

Circle 451 on Page 19

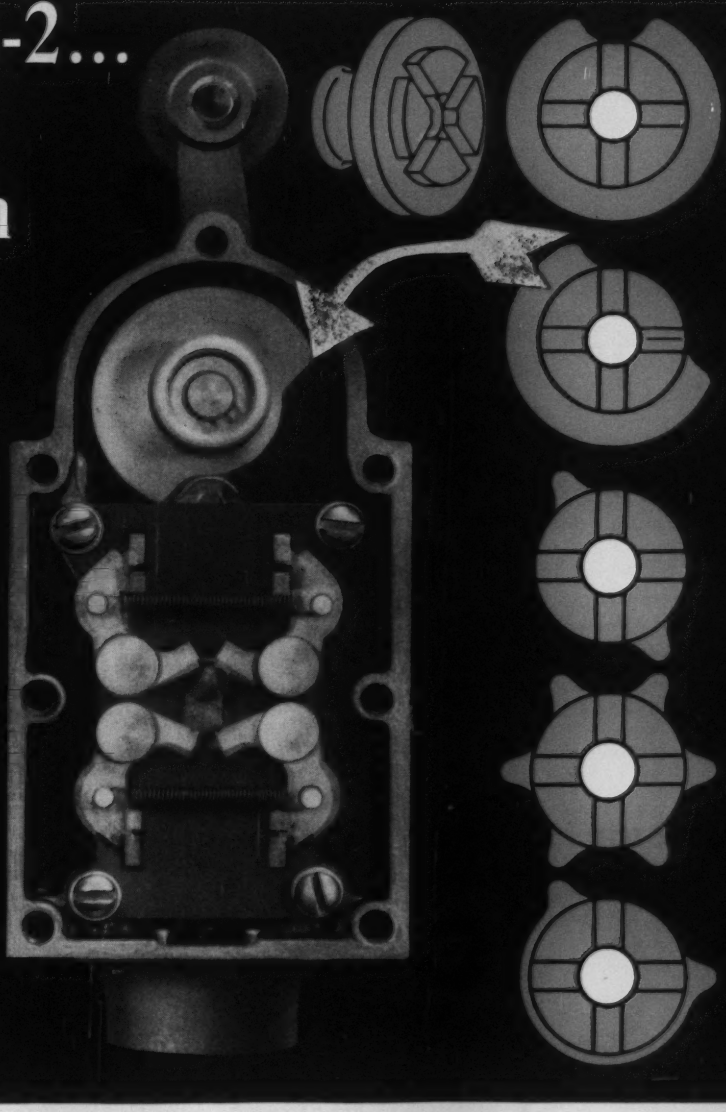


Electric Integrator

Unit is designed for use with the company's linear signal electric flow transmitters. It can also be used for integrating any quantity that can be linearly represented by a dc voltage or current signal in the 0-25 v range, including positive displacement fluid motors driving tachometers, and lineal measurement of webs and strips. Integration is continuous and accurate to within ½ of 1 per cent with flow turndowns of as much as 10 to 1. Model R 790 is insensitive to temperature changes between −30 and +130 F. A dc motor, with speed proportional to the applied voltage, drives the precision gear train and counter. **GPE Controls, Inc.**, 240 E. Ontario St., Chicago 11, Ill.

Circle 452 on Page 19

the new SL-2... a standard limit switch with unlimited operating flexibility



Tailor limit switch performance to your specific job with NAMCO'S *standard* SL-2. This "machine life" limit switch features a standard cam blank which can be cut into a wide variety of configurations to meet any application. These interchangeable cams provide positive control of contact sequence; let you match switch operation to your specific job. Ruggedly built, oil-tight and moisture-proof, the SL-2 provides dependable, accurate performance that meets your most precise requirements.

Now available for low-current, high-shock, excessive-vibration applications...the SLS-2... with full-wiping, self-cleaning sliding contacts that insure "everytime" operation under conditions that spell machine downtime for other limit switches.

Get all the details on how the NAMCO SL-2 line eliminates limit switching problems for good. Write for Bulletin EC-SL260, or contact one of our representatives. You'll find them in all principal cities.

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Circle 730 on Page 19

DRILL and BORE by TAPE COMMAND:

Get .0015 In. Repeatable Accuracy

For Use With Radial Drills and Horizontal Boring and Drilling Machines

Handles drilling thrusts of 5000 lbs. Traverse rate is 150 in. per minute. Deflection, with work load, is .001 in. Absolute accuracy on drilled hole location is .0015 in.

This SWIFT OHIO table — which can be used with a variety of numerical positioning control units — is available in a variety of sizes and travel lengths.

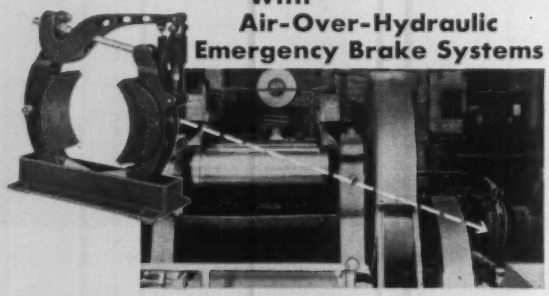
Write or Phone us Today. We'll be happy to send complete details.

SWIFT OHIO CORPORATION KENTON, OHIO

MULTIPLE-OPERATION EQUIPMENT FOR WELDING, MACHINING, ASSEMBLY, SPECIAL MACHINERY

Circle 731 on Page 19

STOP "INRUNNING ROLLS" SAFELY With Air-Over-Hydraulic Emergency Brake Systems



Wagner A/H Emergency Brake Systems protect the operator (as required by safety codes) against the extreme hazards involved in operating machinery with inrunning rolls. An industrial-type brake is applied by an air-operated hydraulic power cluster to stop rolls quickly, smoothly, and with minimum strain on the drive. Systems incorporate safety devices to meet other emergencies, such as loss of air pressure or failure of power supply.

Brake assemblies are ruggedly constructed, are easy to install . . . require no special motor starters or control, no direct current. Maintenance is minimized . . . there is practically no lining wear, no heavy solenoid coils to burn out.

Apply these systems to your rubber or plastic mills, refiners, washers, crackers. Available with 6, 8, 10, 14, or 18 inch diameter brakes. Your nearby Wagner Sales Engineer has the complete story. Call him, soon.

W160-3

Wagner Electric Corporation

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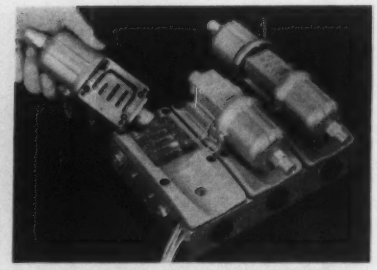
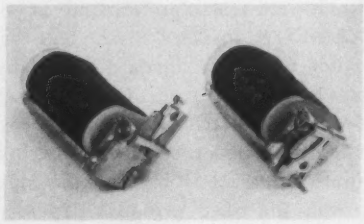
Circle 732 on Page 19



Air Valves

Solenoid operated air valves can be combined to provide a single, compact, and inexpensive manifold to suit any application. Two to ten (or more) manifold-base 4-way valves may be ganged together to form common inlet, common exhaust, and common conduit channels. If more than one pressure is to be used, valves can be isolated and pressure fed from each end of the manifold. First model available in the 1/4 inch series is the single-solenoid, Model 551. Construction of the valve permits interchangeable use of single or double-solenoid operation without demounting the valve. Each manifold base has receptacles with attached leads for quick positive connections. Valve bodies have plugs prewired to the solenoid. Valves may be replaced without disturbing wiring or piping. Every manifold base has both bottom and side ports with suitable plugs, permitting use either way. **Mechanical Air Controls Inc.**, 10030 Capital Ave., Detroit 37, Mich.

Circle 453 on Page 19



Solenoid Acutators

Device is applicable in reciprocating motion, vibration generators, rotary step motion, model actuators, remote switches, valve actuators, and computers. Feature of Model L13 is a linkage system which mag-

With a Fuller Airveyor Conveying System . . .

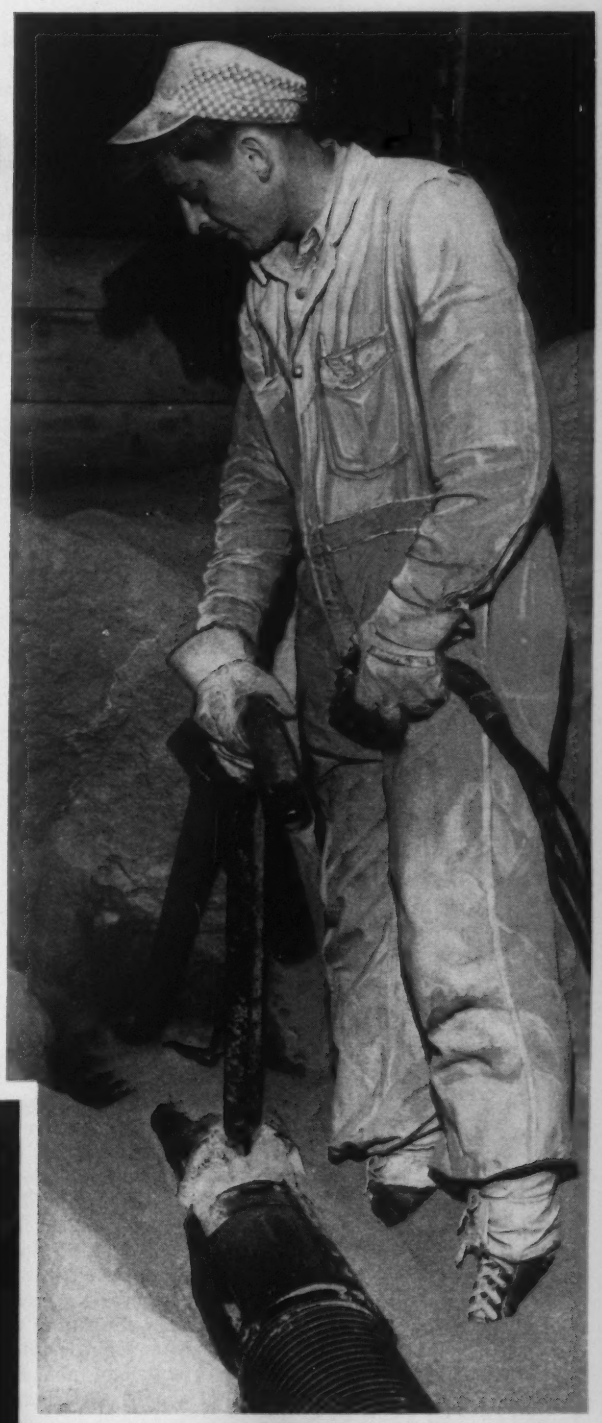
Unloading 30 Tons of Feed Ingredients In Less Than One Hour Is a One Man Job at Ralston Purina

A Fuller Telescopic Airveyor® pneumatic conveying system moves bulk animal and poultry feed ingredients from siding to storage at Ralston Purina's Harrisburg, Pa., mill. The operator keeps the Airveyor nozzle buried in the material by regulating the length of the hose—the telescopic Airveyor conveying system does the rest.

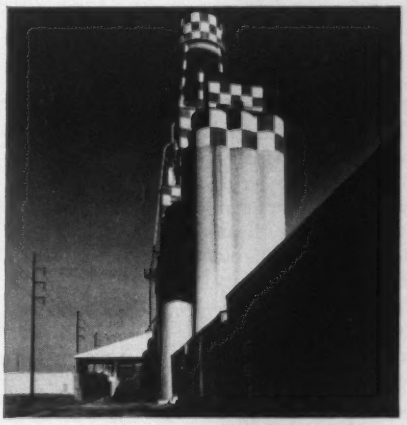
Soybean meal, midds, bran, and other ingredients are sucked vertically 165 feet up 12 stories to any one of 30 storage bins. As the operator works deeper into the car, he simply pushes a button to raise or lower the hose one foot or twenty to reach *any* point within the car. Work never stops to add or take off sections of hose.

Obtaining the savings inherent in bulk purchasing, eliminating the dust hazard, and greatly reducing handling costs are some of the ways Fuller Airveyor conveying systems cut operating expenses in the moving of dry, bulk materials.

Consider the low initial cost and many operating economies of Fuller pneumatic conveying systems when you plan to increase plant capacity. Write or phone today outlining your problem. Fuller will gladly furnish additional information with appropriate recommendation. 1323C A282



Operator controls unloading of feed ingredients at rate of 30 tons an hour — up 12 stories to storage, just by pushing a button.



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FULLER COMPANY
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Fuller
....pioneers in harnessing AIR

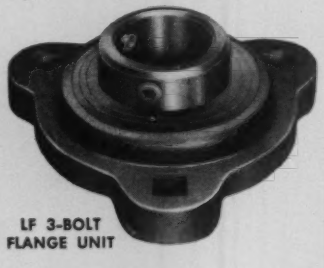
Circle 733 on Page 19

SEALMASTER

"L" SERIES

A HIGH QUALITY LINE OF MALLEABLE HOUSED BEARING UNITS AND BEARINGS AT A COST THAT IS WARRANTED ON YOUR MACHINE!

ECONOMY PERFORMANCE QUALITY



LF 3-BOLT FLANGE UNIT

Available in pillow blocks and two or three bolt flange units for flush or recessed mounting. All units in the "L" Series available with the new SEALMASTER contact type seal.

LP PILLOW BLOCK

LF FLANGE UNIT

LFT FLANGE UNIT

WRITE FOR BULLETIN 359

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PLANTS LOCATED IN: LOS ANGELES, CALIF. CLARKSDALE, MISS. • BELLEVILLE, ONTARIO

Circle 734 on Page 19

nifies the original air-gap movement in an 8 to 1 ratio, delivering maximum pull and stroke from a small input. The actuator may be set for either push or pull by simply reversing the position of the arm. It has a maximum stroke of 0.125 inch, exerting a pull of 100 to 550 grams. Actuator is available for operation on 6, 12, 24, and 48 v. Other ratings from 6 to 148 v dc are available. **James Cunningham Son & Co. Inc.**, 103 Litchfield St., Rochester 8, N. Y.

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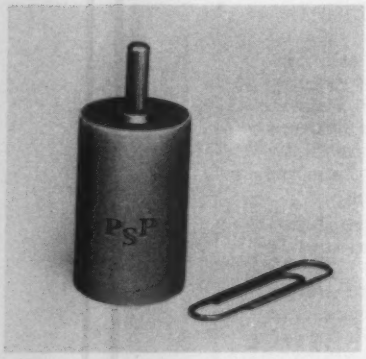

Rotary Solenoid

Unit is suitable for applications where a combination of high torque and precision rotary motion is required. It provides reliable performance under severe operating conditions, such as operation in high temperature environments, in pressurized mechanisms, and for installations where no axial travel of the output shaft can be tolerated, or where the rotary stroke may be externally stopped prior to completion of the normal electromagnetic stroke of the unit. The rotary solenoids can be supplied in any stroke length from 0 to 60 degrees, clockwise or counter-clockwise rotation, with custom-engineered torque characteristics. Operating voltages range from 6 to 300 vdc. Models are available with continuous or intermittent duty windings, and can be equipped with multiple windings for hold-in—with or without switching mechanisms. Other design features include: Low torsional inertia, permanent lubrication, totally enclosed construction, precision hardened alloy torque converter, and dead soft magnetic structure. **PSP Engineering Co.**, 6058 Walker Ave., Maywood, Calif.

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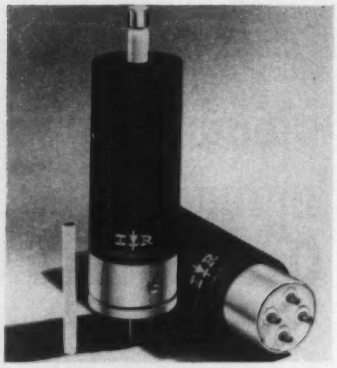
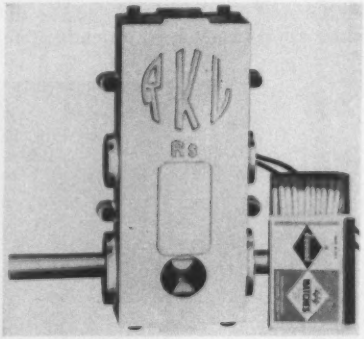


Silicon Rectifiers

Units are designed to provide silicon rectifier operation for short-wave transmitter, radar, industrial rf induction heating and other high-voltage industrial applications. They are rated at 10,000 v peak reverse voltage and 1250 ma dc output at 75C. Models ST-9 and ST-10 are equipped with tube bases to allow direct insertion into existing tube sockets. Their operating temperatures range from −65C to +75C. The entire oil-filled housing of these multiple - junction, hermetically sealed rectifiers acts as a heat exchanger to dissipate the inherently low internal power losses of silicon. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 456 on Page 19



Pinch-Type Valve

Solenoid-operated pinch-type valve can be used for metering, sampling, or *On-Off* control in applications involving corrosive fluids, slurries, dry powders, or sanitary products. Capable of providing absolutely gas-tight shutoff under vacuum or pressure conditions, the new valve is

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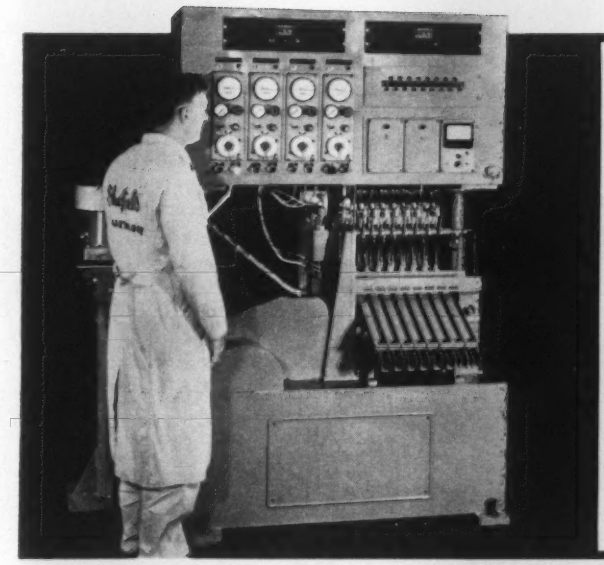

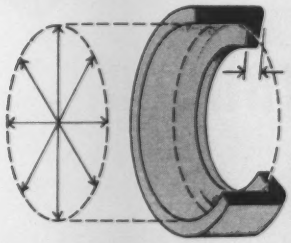

*This Sheffield automatic gaging, classifying and segregating machine inspects up to 2,000 rings an hour for the Western Electric Company. It simultaneously measures inside diameter and flange thickness, classifies rings into 15 sizes plus out of tolerance, and rejects each size in its chute. Its speed and accuracy have resulted in appreciable manufacturing savings.

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Pick it up and call SHEFFIELD for further information on automatic gaging and assembly machines. CL 4-5377, Ext. 211, 212, 213.

The **SHEFFIELD** Corporation Dayton 1, Ohio

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Circle 735 on Page 19

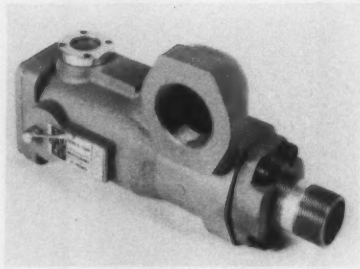
available in sizes up to 1 inch. A normally-closed, energized-to-open valve, Model Rs valve can be operated manually or from programmers, alarms, timers, or automatic sensing instruments. Standard valve bodies are of pure gum rubber with a maximum pressure rating of up to 50 psig for the smallest size. The standard maximum temperature rating is 180 F. There are no moving parts in the fluid stream, and no seats, discs, or packing glands to leak. The simple design principle is completely free of any cavities, and permits straight-through flow in either direction. **RKL Controls Inc.**, Hainesport Industrial Park, Hainesport, N. J.

Circle 457 on Page 19

In-Line Filter

Series of filter body shapes is designed to simplify the intake piping of a pump. The filters are designed in various configurations so they can be installed on an existing pumping unit without the use of elbows. This means that the pressure drop capacity of the pump can be used to tolerate dirt in a filter instead of being completely used to lift the fluid up to pump. An electric limit switch gives remote indication of the filter's degree of clogging. This switch arrangement can be used on machines with automatic controls, telegraphing the filter condition to any point in a plant or tying it in with centralized control panels. Types of filter body shapes available include: Bottom inlets, side inlets, and side outlets. **Rosaen Co.**, 1776 E. Nine Mile Rd., Hazel Park, Mich.

Circle 458 on Page 19



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SERIES
RL
QUICK-CONNECTIVE
RING LOCK
COUPLING

The coupling that's

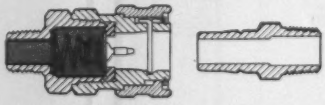
Tougher... Lighter... Smaller

handles more air...with minimum pressure drop
–and gives you all these other advantages–

Has fewer parts. Locking ring provides positive lock . . . tight fit . . . minimum wear. Equipped with automatic sleeve lock.

Handles any job in your shop using ¾" to ⅛" connections—from the air line to the air tool.

All Series 2-RL Sockets and Plugs are interchangeable—likewise all Series 3-RL Sockets and Plugs. Eliminates any need for various size couplings in hook-up—makes it easy to keep stock parts in balance—holds inventories to a minimum.



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Write for the Hansen Catalog

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for LP-Gas, Steam, Oxygen, Acetylene, etc.

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THE HANSEN MANUFACTURING COMPANY

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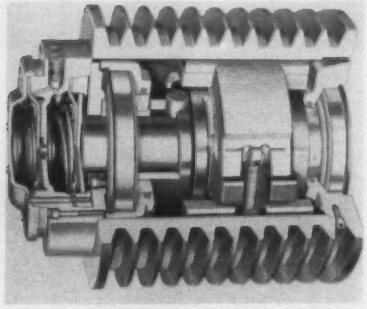
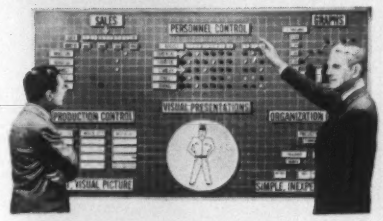


Power Transmission

Accessory unit designated Power-Max is available for use on punch presses, shovels and cranes, rolling mills, extractors, winches, elevators and hoists, ore and rock crushers, centrifuges, ball mills, rotary kilns and any drive where high starting torque, shock loads or other requirements are found. Models are available for direct connection, for v-belt or flat belt drives. They can be provided with an integral brake drum or, since the unit operates in either direction of rotation, the mo-

VISUAL
MAGNETIC
CONTROL



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Maintenance • Machine Loading • Scheduling
Charts • Visual Presentations • Graphs

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SHOW FACTS INSTANTLY
ELIMINATE MISTAKES
GET THE JOB DONE

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106½ WILLOW AVE., STATEN ISLAND 5, N. Y.

Circle 737 on Page 19

Proven, Dependable, Rear-Projection Type
IN-LINE DIGITAL DISPLAYS

A Model and Size for Your Every Requirement

Series 80000
Series 10000
Series 120000

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE SPECIFICATIONS
Representatives in principal cities

PRICES

Series 10000
1 9/16" wide
2 5/8" high
5 5/8" long
$18.00 each

Series 80000
3 1/4" wide
5 1/4" high
11 5/16" long
$33.00 each

Series 120000
1" wide
1 9/16" high
3 7/8" long
$35.00 each

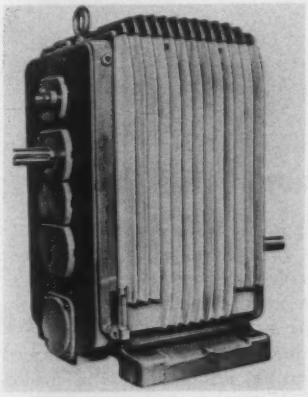
Quantity Prices On Request

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue,
North Hollywood, Calif.

Circle 738 on Page 19

tor can be reversed to act as a brake, without damage to the drive. This device serves three purposes in electric or gasoline engine drives by combining an automatic clutch, adjustable torque selector, and variable starting time delay. It is available in sizes from 3 to 200 hp capacity. The centrifugally-operated clutch can be adjusted both for maximum torque transmitted and time delay in picking-up the driven load. Feature of the unit is that starting load is completely eliminated, even in applications normally having exceptional starting loads. Power requirements never exceed those of the normal running load. **Olme Precision Inc.**, 361 Masonic Bldg., Portsmouth, Ohio.

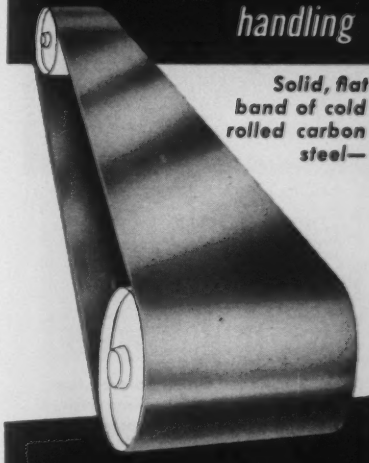
Circle 459 on Page 19



Variable Speed Drive

Constant-horsepower variable speed drive is available for use on such equipment as heavy machine tools, timing, mixing, synchronizing, conveying, and handling systems. It is designed to meet capacities up to 50 hp and ratios up to 5.5:1. Drives of 3.8:1 and less can be directly coupled to a 1750-rpm motor. Drive consists of twin strands of unique single roll chain operating between a pair of facing wheels having a floating center disc. The effective diameters of the wheel faces are altered during operation, changing the ratio and the output shaft speed, thus enabling them to provide stepless adjustment between maximum and minimum settings. Model RS-33 is available in five types: Basic drive, basic drive with output gears, basic drive with input

SANDVIK
Steel Belt
CONVEYORS
have SPECIAL ABILITY
for automated
handling



Solid, flat band of cold rolled carbon steel—

RESISTS OIL, HEAT AND ABRASION

SIMPLIFIES LIVE BACKLOGGING AND AUTOMATIC DISCHARGE

EASILY FITTED WITH SIMPLE GUIDE AND DISCHARGE DEVICES

Contact your nearest Sandvik office

SANDVIK STEEL, INC.
Steel Belt Conveyor Department

SANDVIK STEEL BELT CONVEYORS
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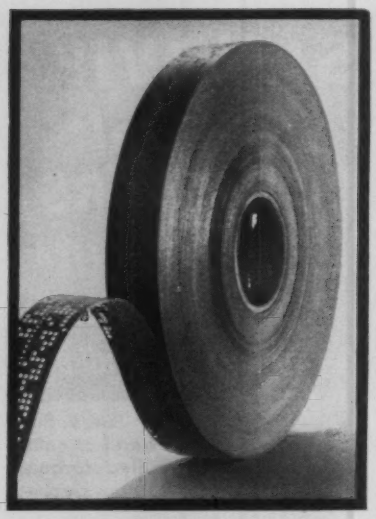
SWarthmore 7-6200
Cleveland • Chicago
Detroit • Los Angeles

IN CANADA: Sandvik Canadian Ltd., P. O. Dr. 1335, Sta. O., Montreal 9, P. Q.

Circle 739 on Page 19



More cycles! No stretch! Less punch wear!

New "Peerless" Fibre control tape wears 30 times longer than paper; costs 1/6th that of polyester film!

Need a tough tape that will take machine shop handling? A durable tape for repeat operations? Check the savings in new "Peerless" control tape. It's made of National Vulcanized Fibre, a cellulose plastic—the only tape of its kind!

Compare "Peerless" tape's long, cost-cutting cycle life:

Speed (CODES PER MINUTE)	Paper Tape (CYCLES)	"Peerless" (CYCLES)
1200	100 to 115	3,000 & over
620	1200 to 1900	30,000 & over

And check "Peerless" tape's amazing properties! It's extra tough, flexible, with high tensile and bending strength. It has high opacity, excellent abrasion resistance and is easily punched. Thicknesses: .0043" and .005"—heavier thicknesses available.

"Peerless" does not stretch in use. Precision-punched holes remain true. In addition, "Peerless" is *plastic-smooth* and impurity-free; friction and wear on punching and feeding equipment are cut to the minimum.

"Peerless" tape is available in any width. It is already proving its superior economies in tape life and cost on major automatic programming equipment in industry, government and business. Colors: Red, Gray, Blue, Black. Investigate now. Write for Free test sample and complete information. Dept. PP-8.

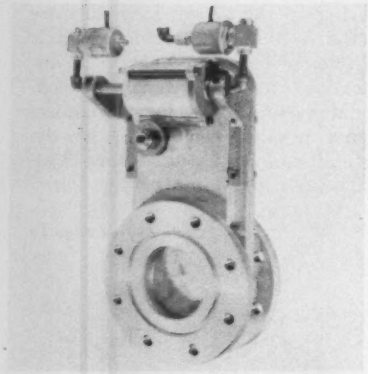
NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

Circle 740 on Page 19

and output gears, basic drive with integral foot-type motor, and basic drive with integral foot-type motor and output gears. **Link-Belt Co.**, Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 460 on Page 19



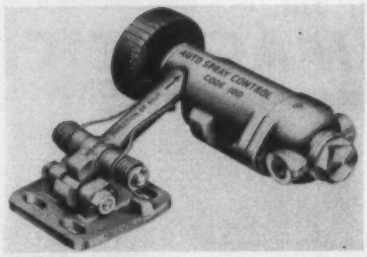
Remote Valve Operator

Device is designed for control of high vacuum gate valves. It can effect 180 degrees of rotation of a valve stem. The valves can be operated at pressures as low as 50 psi due to the torque developed. Operating principle of the unit is based upon a simple rack-and-pinion. The piston is fixed and the cylinder carries the rack. Air moves the cylinder to turn the pinion gear mounted on the valve stem. This design permits the operator to read the position of the gate at the valve location. Remote indicators can also be installed. Valve operator can be wired to effect automatic, instant closing or opening, according to need, in case of power failure. **Vacuum Research Co.**, 420 Market St., San Francisco 11, Calif.

Circle 461 on Page 19

Spray Control

Unit designated Conflow Code 100 Auto Spray Control is designed to automatically control supplies of water and fluid sprayed or sprinkled onto transported materials such as asbestos, coal, coke, granite, gravel, iron and other ores, sand, and stone. Rotary motion is the principle of actuation, and driving wheel rotation is imparted by the material transporter itself, by deflection of the top carrying belt in conveyor installations, and in other applications by moving trucks, cables, rotary equipment, and shafts. The unit is self contained, does not require source of power. Upon rotation of the driving pulley in the proper direction a gear pump delivers special hydraulic fluid at low pressure from a reservoir to the rear of a piston which moves forward carrying with it a pushrod, thus lifting the control valve from its seat. Stoppage of rotary motion causes the control valve to close. Water, or other liquid, passes through the valve section of the unit to effect cooling, but it is isolated from the unit hydraulic circuit. **Megator Corp.**, 930 Manchester Ave., Pittsburgh 12, Pa.



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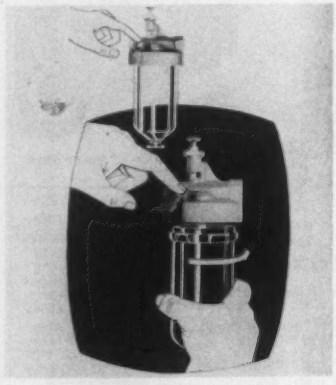
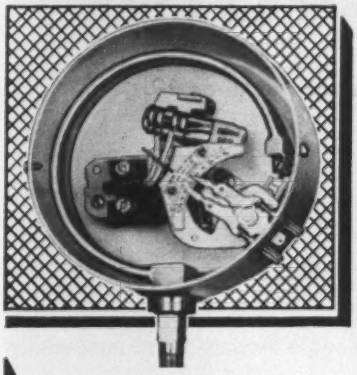


Airline Lubricator

Device is designed to provide constant and precisely controlled lubrication to all compressed air operated tools and equipment. With only one adjustment, the lubricator

316 STAINLESS STEEL

Welded Bourdon Tube and Pressure Connection



A NEW ADDITION to MERCOID PRESSURE CONTROLS

Series D-41, 243, 541

316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.— with varying differentials and electrical capacity to meet your application.

Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

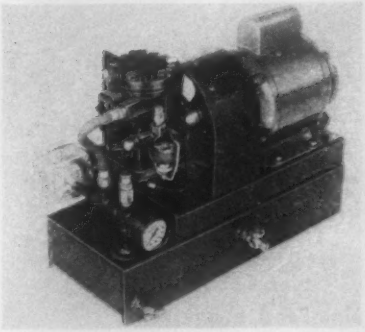
WRITE FOR BULLETIN 019

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

Circle 741 on Page 19

will inject an oil fog into an air stream flowing as little as 1 cfm, up to the full flow that can go through the pipe line. It is available in ¼, ⅜, and ½ inch female pipe threads, and cannot be used in temperatures above 120 F or for air pressures above 150 psi. Model 3014 features a quick change bowl which holds 12 ounces of lubricant. By pressing a locking lever, and twisting the bowl, the transparent bowl can be removed. It is not necessary to turn off the air line to do this. **Wilkerson Corp.**, 1552 W. Girard Ave., Englewood, Colo.

Circle 463 on Page 19



Air Compressor

Air compressor with 1/3 hp at 1725 rpm has a piston displacement of 2.70 cfm, and operating range of 100 psi. It has forced feed oil pressure lubrication and a self-contained air cooling fan. Oil supply is clearly visible and sealed against contamination. Motor and compressor are resilient mounted minimizing transmission of vibration. Leaf type exhaust valve eliminates the need for a check valve and direct coupling of pump and motor assures positive power transmission with no slippage as in belted equipment. Air supply is stored in rectangular steel welded tank with internal baffles. Unit is equipped with moisture drain cock, pre-set safety valve, automatic stop-start air pressure switch, air pressure gauge, heavy-duty fittings, and air outlet needle valve. Compressor is being made available for incorporation as a self-contained compressed air supply. **Ajax-National Air Compressor, Div., Ajax Equipment & Electric Co.**, 229 Centre St., New York 13, N. Y.

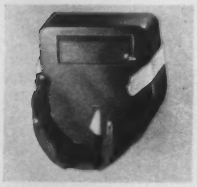
Circle 464 on Page 19

NEW STROMBERG-CARLSON TELEPHONE HANDSET CRADLE

. . . for positive retention in all mobile applications

There's no jump, no sway—when a telephone handset is in the firm grip of this new handset cradle by Stromberg-Carlson.

Retaining clip spring assembly assures positive retention in any mobile application on land or sea, or in the air. Even extremely severe jars, jolts and vibrations fail to dislodge the handset.



The cradle is strong and resilient, fits any Stromberg-Carlson handset. Different models provide varying switch combinations with 2 or 4 Form C contacts. All models available with or without the clip assembly.

Specifications on request. In Atlanta call TRinity 5-7467; Chicago: STate 2-4235; Kansas City: HArrison 1-6618; Rochester: HUbbard 2-2200; San Francisco: OXford 7-3630. Or write to Telecommunication Industrial Sales, 111 Carlson Road, Rochester 3, New York.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

Circle 742 on Page 19

AUTOMATION

catalogs and literature

Latest automation information. For copies use card on page 19.

Numerical Control

Pratt & Whitney Co. Inc., Charter Oak Blvd., West Hartford 1, Conn.—12 *page bulletin*—Data are given in Bulletin 639 on point-to-point numerically controlled positioning equipment. Details are given on machines providing the following types of numerical controls: Tape control of a single axis, of two axes, of three axes, and of a spindle. These machines include jig borers, linear-rotary combination machines, and rotary tables.

Circle 465 on Page 19

Infrared Heating

Radcor Inc., Subsidiary, Edwin L. Wiegand Co., Bradner, Ohio—8 *page bulletin*—Line of infrared heating equipment and infrared ovens is described in Bulletin BRG100. The equipment in the line consists of components, modular oven sections that can be used singly or constructed in custom form, and a group of oven units. Types of ovens include batch, vertical, horizontal, tower, and ovens for use with monorail or floor-type conveyors.

Circle 466 on Page 19

Brakes and Clutches

Warner Electric Brake & Clutch Co., Beloit, Wis.—6 *page pamphlet*—Data on brakes and clutches ranging from 1/50 to 100 hp are described in Bulletin P-78. The operating principle of electric motion control is described in detail. A schematic drawing shows the principle of operation when the clutch is engaged and disengaged.

Circle 467 on Page 19

Electronic Checkout Equipment

Packard Bell Electronics, 12333 W. Olympic Blvd., Los Angeles 64, Calif.—12 *page booklet*—Data are given in this booklet on a line of automatic checkout equipment. Described in detail are the two consoles comprising the standard equipment. The systems control set is a director or controller for the second unit, the test console. Some of the other features covered include: Assembly and availability information, maintenance unit, pyrotechnical test unit, and pulse generator.

Circle 468 on Page 19

Dial Feed Mechanism

Taylor Winfield Corp., 1048 Mahoning Ave., Warren, Ohio—12 *page bulletin*—Data are contained in Bulletin 8-213 on a dial feed mechanism for resistance welders. Drawings show the Geneva index mechanism in two different positions—at the beginning of motion and during motion. Numerous case histories are outlined. Illustrations show automatic loading, unloading, and inspection operations.

Circle 469 on Page 19

Automatic Handling

General Mills Inc., Nuclear Equipment Dept., 419 N. 5th St., Minneapolis 1, Minn.—4 *page pamphlet*—Subject of this pamphlet is a system of programmed manipulation, employing a mechanical arm operated by an analog controller. Details are given on recording movements of the arm, operation of the system, automatic programming, and system accuracy. Areas of possible application are listed.

Circle 470 on Page 19

Drum Sort Program

Remington Rand Univac Div., Sperry Rand Corp., 315 Park Avenue South, New York 10, N. Y.—17 *page booklet*—A method of using a computer drum sort to place items in ascending sequence is discussed in Booklet U1887. The program, designed for use on the Model 1 Univac File-Computer, can sort one drum of 24 character unit records containing an identifier in the first word and an amount in the second word. Details are given on the principle of the program which is a three way comparison between an item on the high end of the source drum, an item on the low end of the source drum, and the last item written on the destination drum.

Circle 471 on Page 19

Toggle Switches and Assemblies

Micro Switch, Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.—32 *page catalog*—Applications, features, and specifications on high-performance toggle switches and toggle switch assemblies are contained in Catalog 73d. Types of switches described include bushing-mounted, pull-to-unlock, hermetically sealed, and rocker-actuated. The catalog is complete with detailed descriptions, photographs, diagrams, dimensional drawings, and specifications.

Circle 472 on Page 19

Press Equipment

U. S. Tool Co. Inc., Ampere (East Orange), N. J.—21 *page booklet*—Line of press room equipment is described in Bulletin 85-60. Included in the line are slide feeds, roll feeds, stock reels, stock straighteners, and coil cradles. Noted are various features of construction and methods of operation.

Circle 473 on Page 19

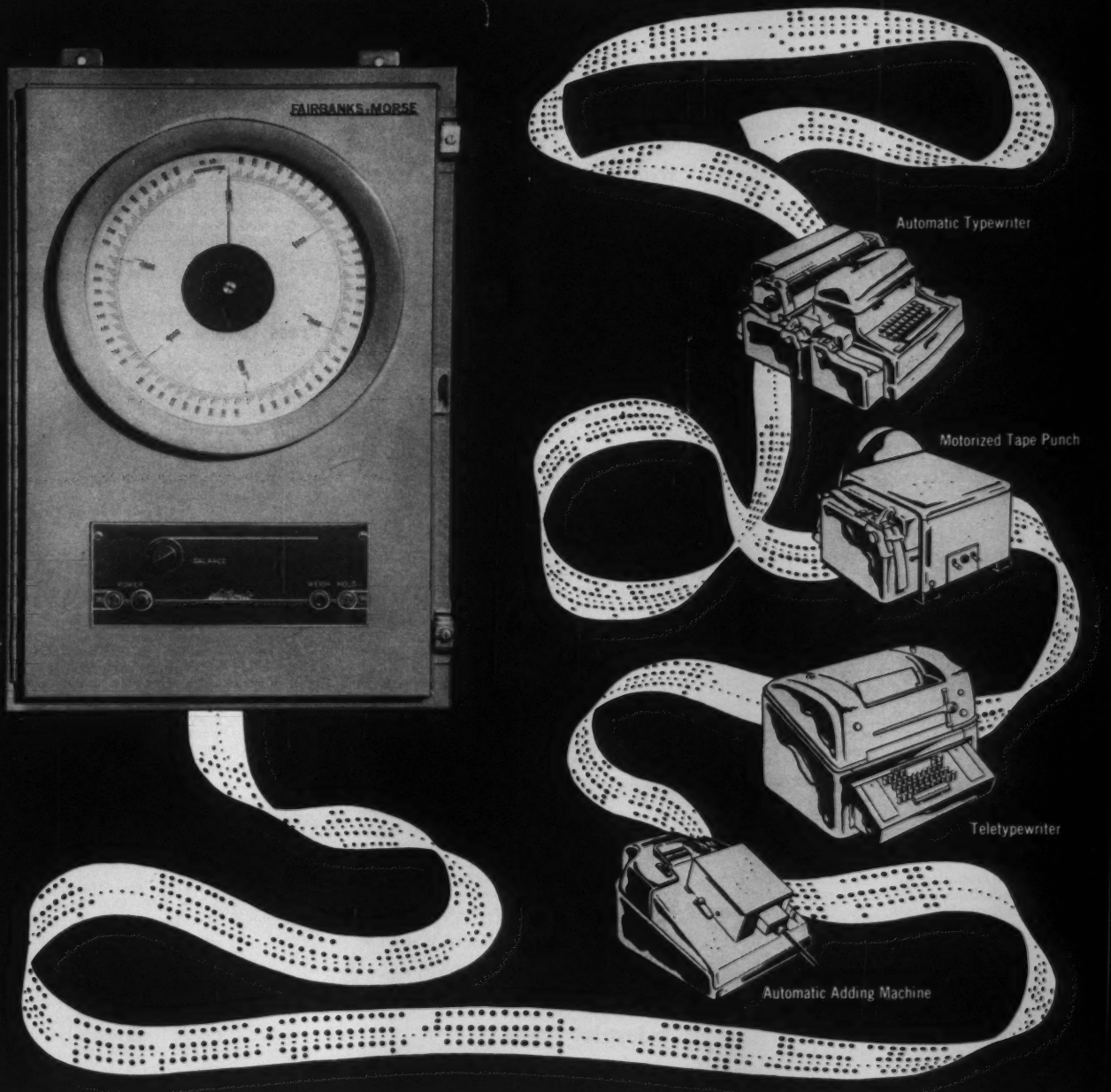
Lubricating Equipment

Oil-Rite Corp., 2312 Waldo Blvd., Manitowoc, Wis.—8 *page bulletin*—Lubricating equipment such as oil cups, chain oilers, dispensers, liquid level gages, sight feed valves, and spray systems are outlined in Bulletin X-135. Notes are given on oiling systems operated by gravity, by air pressure, or by a gear pump. A price list is also included.

Circle 474 on Page 19

Milling Machine

Marac Machinery Corp., 108 Grand St., White Plains, N. Y.—12 *page booklet*—Subject of this booklet is a numerically



To translate electronic weight messages this Fairbanks-Morse CDO converter speaks their language

The Fairbanks-Morse CDO unit actually translates weight messages from an electronic load cell into one of several languages "spoken" by automatic business machines. It provides a rapid, accurate conversion from analog to digital transmission, bringing together weight and associated process data to a central location. Delay and error are eliminated as is the need for intermediate records.

and yours, too!

When it comes to saving time and money, the Fairbanks-Morse CDO Converter speaks *your* language, too! Its instant "read-out" of weights and other information promotes efficient inventory control, accounting, costing, billing and other essential procedures. When used with the F-M Electronic Program Control Systems, the CDO Converter can operate with the card reader to "sequence-feed" data in chronological order.

The Fairbanks-Morse CDO Converter is housed in a moisture-resistant, dustproof case designed for wall mounting. A table-mounted case is also available. For more information write to Fairbanks, Morse & Co., Electronics Division, West Hartford 1, Connecticut.

Fairbanks, Morse

ELECTRONICS DIVISION

A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY CORPORATION

Circle 743 on Page 19

controlled boring and milling machine, designated Schwartzkopff KBF2, manufactured in Western Germany. The details of the input means which include co-ordinate drums and punched cards are given as well as table options to match the various applications. How the gaging system of each axis of the machine operates is also described in detail. Application photos are included.

Circle 475 on Page 19

Circuit Boards

Digital Equipment Corp., Maynard, Mass.—8 page bulletin—Line of 5 megacycle, plug-in, system building blocks is described in Bulletin C-1000. The units include single, dual, and quadruple flip-flops; inverters; diodes; decoders; delays; delay lines; clocks; and pulse generators. The logical characteristics of the system building blocks are explained, and notes are given on accessory equipment and high current pulse equipment.

Circle 476 on Page 19

Purchase Order Writing

Friden Inc., 2350 Washington Ave., San Leandro, Calif.—14 page booklet—This report describes in detail a purchase ordering system using punched card Flexowriter equipment. The steps covered in this system include: Writing the order, converting the order from tape to IBM cards which are then analyzed, preparing a quotation when needed, and sending followup letters. Described also are multiple uses of both machines and data inputs.

Circle 477 on Page 19

Slurry Pump

Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 13, Pa.—4 page pamphlet—Bulletin 1158 covers the Oliver diaphragm slurry pump which is capable of metering slurries with up to 60 per cent solids at a controlled volume accuracy of ±2.0 per cent. It is explained how flow volume can be varied from 0 to 180 gph at pressures to 90 psi by remote control electric timer or electrical probe mechanism. Schematic diagrams show the action of the pump.

Circle 478 on Page 19

Servomotors

Helipot Div., Beckman Instruments Inc., 2500 Fullerton Rd., Fullerton, Calif.—16 page booklet—Line of Size 18 servomotors and servomotor-rate generators described are for 115 v, 60 or 400-cycle operation. Data are included on an inertia-damp unit for 115 v, 400-cycle operation. Notes are given on unit characteristics, and drawings show torque-speed curves and corner frequencies.

Circle 479 on Page 19

Packaging Machine

Sundstrand-American Broach, Div., Sundstrand Corp., Ann Arbor, Mich.—6 page pamphlet—Packaging machine described in Bulletin 50A-1 can package hard and soft goods at rates up to 150 per minute. Details are given on a feature of the machine —the quick-change sealing rolls. Also discussed is the automatic vertical vibratory feed unit.

Circle 480 on Page 19

Hydraulic Accumulators

Parker Hydraulics Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio—4 page pamphlet—Data on piston-type accumulators ranging in capacity from 10 cubic inches to 10 gallons are given in Bulletin 1530B1. It is explained how the 5-blade Parker V O-ring piston sealing feature maintains full contact between piston and wall without rolling, even under rapid cycling. The bulletin is illustrated with several hydraulic diagrams of typical circuits.

Circle 481 on Page 19

Chromatographic Instrument

Perkin-Elmer Corp., Norwalk, Conn.—36 page catalog—A new gas chromatography instrument designated Model 154-D Vapor Fractometer is described in Catalog KHV2607.5. Details are given on the heart of the instrument, the gas chromatography column. Numerous graphs show the typical separation performed by different columns containing a production substrate. Four detectors which can be used for a variety of analyses with chromatograph are also described.

Circle 482 on Page 19

Timers

Automatic Timing & Controls Inc., King of Prussia, Pa.—30 page catalog—Catalog D-31 covers line of timing components and linear measuring systems. Test equipment, switches, controllers, contactors, and valves are described. Data are also given on differential transformers, motion transmitters, edge guide pressure transmitters, demodulators and indicators, and recorders. There is also information on a proximity limit switch, hydraulic servo valve, set point transmitters, and zero adjusts.

Circle 483 on Page 19

Industrial Tubes

Distributor Products Div., Raytheon Co., Westwood, Mass.—8 page bulletin—Bulletin SP7069 lists in short form over 900 types of tubes and their interchangeabilities. This includes miniatures, subminiatures, voltage regulator-voltage reference, radiation counter, pencil, transmitting, amplitron, traveling wave, oscillator, amplifier, photosensitive, ignitron, and industrial cathode ray.

Circle 484 on Page 19

Data Plotting Instrument

Electronic Associates Inc., Long Branch, N. J.—8 page bulletin—Data are given in Bulletin DP6001 on a digital data plotting instrument, designated Dataplotter. The instrument can convert digital information from punched cards, punched paper tape, or a manual keyboard. Details are given on the vacuum hold-down system and the automatic scale factor and parallax setting. Areas of applications are listed.

Circle 485 on Page 19

Snap-Action Switches

Cherry Electrical Products Corp., 1650 Deerfield Rd., Highland Park, Ill.—16 page booklet—Features, operating characteristics, and ordering information are given in Booklet 560 on a line of precision snap-action switches. A number of technical terms applying to all snap-action switches are defined. Schematic diagrams and photos of the various switches are included. Three nylon insulators are also described and illustrated by diagrams.

Circle 486 on Page 19

Press Feeder

Hudson Div., Emhart Mfg. Co., Hudson, N. Y.—8 page bulletin—Subject of this bulletin is precision power press feeder designated Feed-O-Matic. This feeder can handle parts ranging in size from very small to pieces up to 10 or 11 inches in length. Details of the operation are given with photos showing the functions of the different parts.

Circle 487 on Page 19

Meter-Relays

Assembly Products Inc., 75 Wilson Mills Rd., Chesterland, Ohio—16 page booklet—Nonindicating meter-relays designated VHS are discussed in Bulletin 104-G. The VHS has no meter except in special modifications. Its sensitivity begins at 0.2 microampere. Models 137 and 126 are described and accompanied by schematic diagrams. Diagrams are also used to illustrate meter-relay contact arrangements and internal connections, how it works, and circuitry.

Circle 488 on Page 19

Static Frequency Converter

Magnethermic Div., Ajax Magnethermic Corp., P. O. Box 839, 3990 Simon Rd., Youngstown 1, Ohio—6 page pamphlet—Subject of Bulletin 1059 is a static frequency converter, designated Multiductor, designed for induction melting and heating applications. Details are given on the operation of the unit. Charts given include one showing the typical melting performance of the converter and a frequency selection chart for steel bar stock heated to forging temperature.

Circle 489 on Page 19

Controlled Tension Winders

Temco Winder Div., Sealol Inc., Providence 5, R. I.—6 page pamphlet—Controlled tension winders for automatically winding paper, plastics, textiles, rubber, metal, and wire are described in Bulletin W01. Construction and operation of the winders is explained, aided by a schematic diagram.

Circle 490 on Page 19

Electron Beam Welding Process

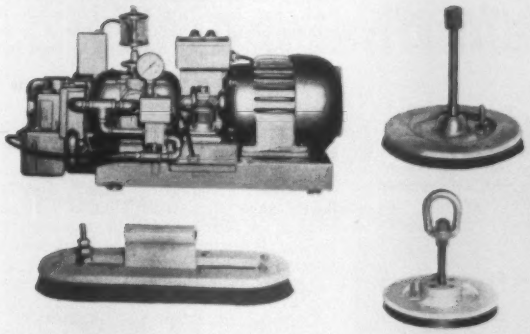
Air Reduction Sales Co., Div., Air Reduction Co. Inc., 150 E. 42nd St., New York 17, N. Y.—12 page booklet—Data relating to electron beam welding are contained in Bulletin ADC 937. All of the salient features, how the process operates,

VAC-U-LIFT

HAS THE SOLUTION!

Vacuum handling is faster, safer, and more economical

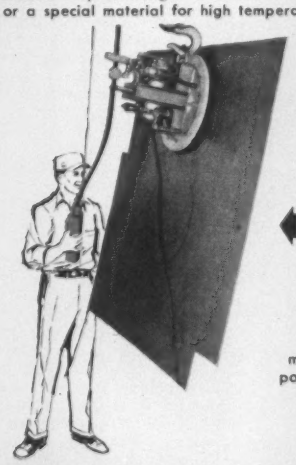
1. COMPONENTS



POWER-PACS are ⅓ to 3 horsepower with patented automatic valves and safety reserve tank as integral parts... in deluxe or compact models.

VACUUM PADS range in size from ½ inch to 24 inches in diameter with lifting capacity of a single Pad from a few ounces to more than one ton.

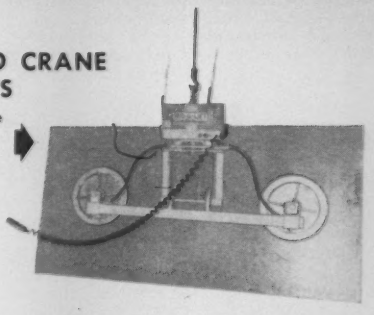
SEAL RINGS attached to the vacuum Pads can be the bolt-on type, or the patented snap-on design. Available in Neoprene, Silicone, Sponge, or a special material for high temperature applications.



2. STANDARD HOIST AND CRANE VACUUM ATTACHMENTS

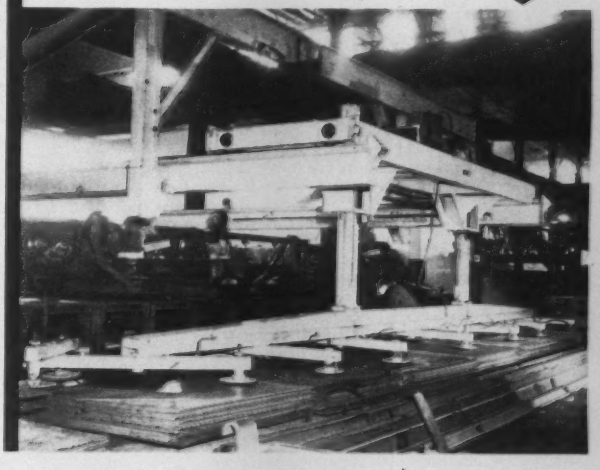
Single and multi-pad units are available to perform many tasks within the same plant. They are compact and ruggedly constructed. Stone, plastic, steel, wood, glass and structurals are just a few of the materials now being lifted and handled with vacuum.

VAC-U-LIFT attachments will lift material in a vertical or horizontal position, tilt, or turnover with instantaneous vacuum attachment and detachment.



3. STANDARD VACUMATIC VACUUM UNITS

Self contained units specially designed to operate from an overhead track mounted on superstructure with lift and traverse motion to give controlled delivery of material to production equipment. These push button operated units can be completely automatic or semi-automatic.



WHAT'S YOUR PROBLEM?

Your particular operation or problem may not be illustrated here, but if you do have a handling problem let VAC-U-LIFT'S experience and engineering know-how through the expert use of vacuum help you. VAC-U-LIFT systems are currently being used to control, position, and maneuver a multitude of materials weighing from a few ounces to 20 tons.

All VAC-U-LIFT units carry a full 3 month unconditional warranty.

Write, wire or call . . .

the VAC-U-LIFT COMPANY, Salem, Illinois, or get in touch with your nearest VAC-U-LIFT representative for help with your handling problems.

VAC-U-LIFT CO., Dept. VL-182, Salem, Ill.

Division of the Siegler Corporation

Circle 744 on Page 19

the principal advantages, and the equipment required are covered. A schematic drawing of an electron beam gun is also included.

Circle 491 on Page 19

Balancing Machines

Gisholt Machine Co., Madison 10, Wis.—8 page bulletin—Machines described in Bulletin 1207 are for balancing small high speed rotating parts or assemblies containing high speed rotating parts. Data are given on machines indicating by stroboscopic lamps and by expanded scale tachometers. Numerous installation photos are included. A block diagram shows the operational sequence of the balancer.

Circle 492 on Page 19

Magnetic Components

Eriez Mfg. Co., Erie, Pa.—6 page pamphlet—Data are contained in Bulletin B-82-1A on components, designated Magnamation, for automated conveying, elevating, and controlling operations with or without belts. Details are given on permanent nonelectric rails and rolls. Installation diagrams for rails are given as well as construction data.

Circle 493 on Page 19

Varistors and Thermistors

Victory Engineering Corp., 505 Springfield Rd., Union, N. J.—12 page booklet—Data on varistors and thermistors are contained in Catalog V-507. Types of thermistors include bead, rod, disc, and washer types and types of varistors are disc and washer. Definitions covering common terminology used in the application of thermistors and varistors are given. Also listed are designers' kits, experimenters' items, thermal conductivity cells, temperature sensor assemblies, and "chopperettes."

Circle 494 on Page 19

Press Equipment

Hydraulic Press Mfg. Co., Div., Koehring Co., Mount Gilead, Ohio—16 page booklet—Line of press equipment for pressure processing is described in Bulletin 6000. Illustrated and described in detail are metalworking presses, process presses, C-frame presses, dieing machines, diecasting machines, and plastic molding machines. Hydraulic components such as power units, variable displacement and fixed displacement pumps and motors, directional and functional valves and cylinders are also listed.

Circle 495 on Page 19

Metering Pump

Associated Control Equipment Inc., P. O. Box 136, Coraopolis, Pa.—4 page pamphlet—Subjects of Bulletin P-21 are pneumatically powered and controlled metering pumps with capacities ranging from 0.12 to 82.5 gph. Schematic diagrams illustrate typical applications which include simple metering, flow ratio control, process variable control, and multiple proportioning.

Circle 496 on Page 19

Precise-Power Systems

Electric Specialty Co., Application Engineering Dept., 211 South St., Stamford, Conn.—8 pamphlets—Data on precise-power systems for the electronics industry are given in these bulletins. A precise-power set is defined as a rotary electromechanical system, usually regulated and/or controlled by static circuitry. Details are given on the following: Application of power sets to large electrical systems, motor-alternators for ac-dc power conversion, field-current regulators generators, sensing elements, signal amplifiers, power amplifiers, and control systems and switchgear.

Circle 497 on Page 19

Recorders

Hogan Faximile Corp., Subsidiary, Telautograph Corp., 155 Perry St., New York 14, N. Y.—16 page booklet—This booklet contains data on a line of high speed recorders. Details are given on printer plotters, graphic recorders, graphic recorder analyzers, and marking amplifier systems. Photos of each recorder are included.

Circle 498 on Page 19

Boxes and Crates

Wirebound Box Manufacturers Assoc., 327 S. La Salle St., Chicago 4, Ill.—8 page pamphlet—This bulletin contains information on materials handling, stacking, and warehouse applications of boxes and crates. Construction principles of the boxes and crates are explained in detail. A photo is used to illustrate an example of vertical warehousing showing the use of warehouse "air rights" by high stacking. Other application photos are included.

Circle 499 on Page 19

Computer

Control Data Corp., 501 Park Ave., Minneapolis 15, Minn.—16 page booklet—Subject of booklet is Model 160, a desk size computer. List of 62 instructions with execution speeds is given. Also included are descriptions of three operational registers and three transient registers, and various addressing modes. Details are given on the input-output lines.

Circle 500 on Page 19

Industrial Strainers

Tate Engineering Inc., 516 S. Eutaw St., Baltimore 1, Md.—88 page catalog—Catalog contains data on line of industrial strainers for intermittent and continuous flow systems. Notes are given on the layout of fluid flow systems and sizing of strainers. Numerous charts show test results of pressure drop, temperature, and viscosity.

Circle 501 on Page 19

Thermocouples

Bristol Co., Waterbury 20, Conn.—6 page pamphlet—Line of thermocouples designated Armorox is described in Bulletin P1281A. Metal-sheathed, ceramic insulated construction of the thermocouples is explained, and typical applications are cited. Included is a table giving complete specifications of various thermocouples available.

Circle 502 on Page 19

Sheeting Equipment

F. J. Littell Machine Co., 4101 N. Ravenswood Ave., Chicago 13, Ill.—12 page booklet—Data are given in Bulletin G-10 on high speed sheeting lines. Equipment in the line includes sorters and stackers, roll feed and cut-off machine, straightening machine, and spindle reel and coil loading car. Details are given on a roll feed that feeds up to 125 strokes per minute, a 16-roll straightener and a reel with track-mounted loading car that handles coils up to 20,000 lb.

Circle 503 on Page 19

Hydraulic Presses

Denison Engineering Div., American Brake Shoe Co., 1160 Dublin Rd., Columbus 16, Ohio—24 page catalog—Subjects of Bulletin 120 are hydraulic presses ranging in capacity from one to 75 tons. Types of control applicable to these presses are explained, and valves used with the various controls are listed. The presses described are divided into seven series according to capacity. A cutaway drawing of a typical press is also included.

Circle 504 on Page 19

Data Processing Center

McDonnel Automation Center, Div., McDonnel Aircraft, Box 516, St. Louis 66, Mo.—12 page booklet—Electronic data processing service offered by company is discussed in bulletin. It is explained how the equipment can be used for systems design, programming, computing, tabulating, and training, and processing of administrative data. Applications of the equipment in both the business and scientific field are noted.

Circle 505 on Page 19

Switches

Haydon Switch Inc., Waterbury 20, Conn.—8 page bulletin—Line of plastic-cased switches and actuators is covered in Catalog 12. The types of switches described include: Precision snap-action, subminiature, 5200 series (miniature snap-action), and toggle-actuated series 5300. Schematic diagrams illustrate the 5300 series with integral actuators. Photos of other available switches are also included.

Circle 506 on Page 19

Batching System

Howe Scale Co., Subsidiary of American Mfg. Co. Inc., Rutland, Vt.—12 page booklet—Subject of Bulletin MC-1-60 is an automatic batching system applicable in chemical, abrasive, grain, refractory, plastic, and brewery processing. The three principal systems used in batching units are described. Notes are given on the controls and indicators used. Suggestions are included on how to plan an automatic batching system.

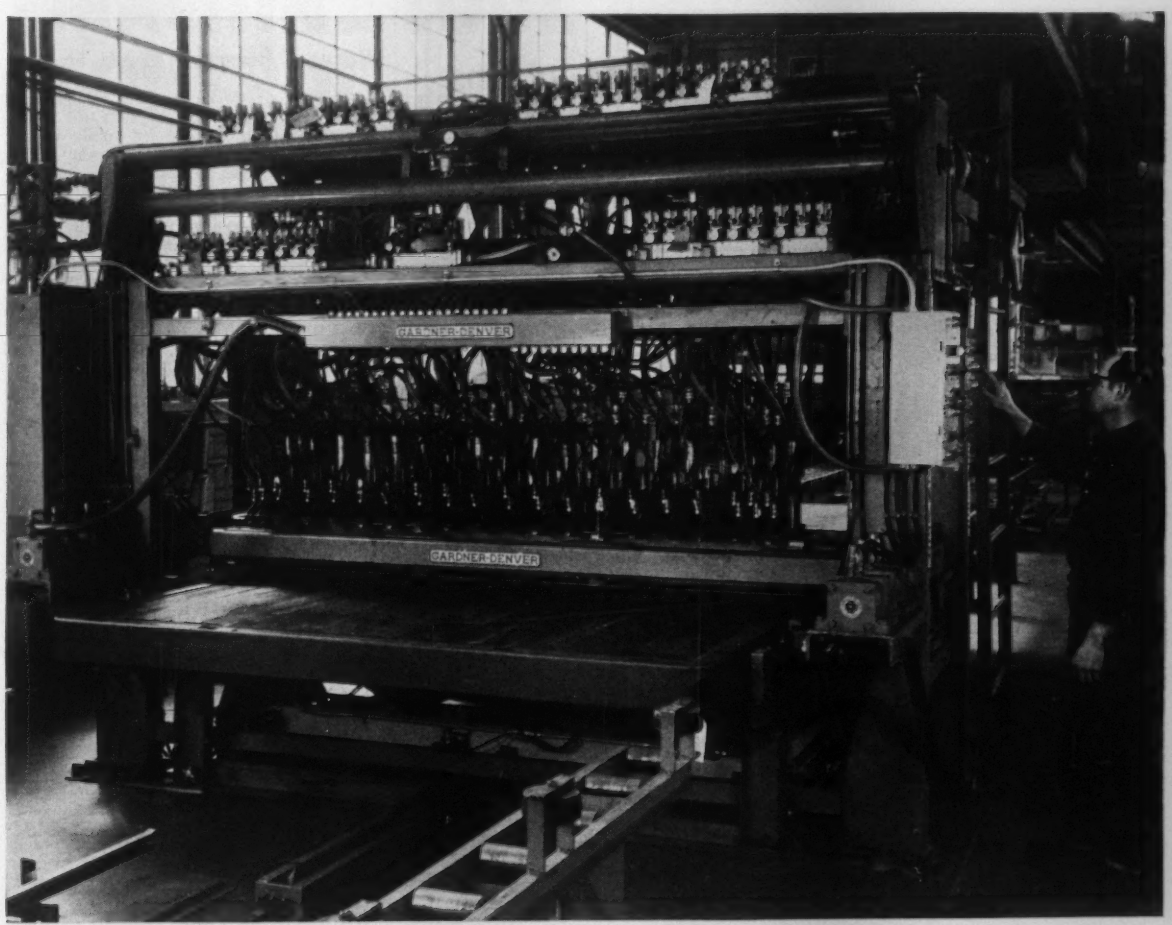
Circle 507 on Page 19

DRILL FEED DRIVE

with one automatic machine

Here's a push-button, air-powered machine specially designed and built by Gardner-Denver to drill holes, feed and drive screws automatically in a truck bed. Machine carries 20 Airfeedrills® and 20 screw drivers on a cross slide—enabling it to handle up to 40 holes in a row. Truck bed automatically positions itself for the next row of holes.

This is typical of how Gardner-Denver custom-designs production machines to automate any drilling or fastening job—saving time and money. For details, contact your Gardner-Denver air tool specialist or write for information.



Gardner-Denver production machine drills wood and metal truck body—sets ¼" x 2¼" self-tapping screws automatically at rate of 4560 per hour.

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Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 745 on Page 19

Storage Structures

Sprout, Waldron & Co. Inc., 130 Logan St., Muncy, Pa.—4 page pamphlet—Described in Bulletin 207-A is a variety of storage structures for animal feeds, flour, food, chemical, and industrial products. Photos show bolted steel storage structures, square-type storage tanks, live bottom storage bins, and special bins.

Circle 508 on Page 19

Roller Bearings

Hoover Ball & Bearing Co., 5400 S. State Rd., Ann Arbor, Mich.—16 page booklet—Data are given on a line of spherical roller bearings in Bulletin 113. Super finish rollers, super finish raceways, machined bronze retainers and other important design features are discussed. Charts indicate bearing load ratings, dimensions, and radial load capacities.

Circle 509 on Page 19

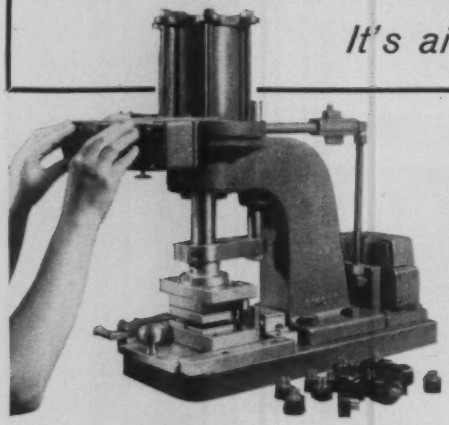
Solenoid Valve

Automatic Controls Div., Hays Mfg. Co., 801 W. 12th St., Erie, Pa.—2 bulletins—Data on solenoid valve designated Electro-Mite are contained in two bulletins. Bulletin 2150-3 describes a moisture proof solenoid and Bulletin 2154-7 describes the Electro-Mite with a new waterproof coil. Also included is ordering information for both types.

Circle 510 on Page 19

Solve your "Small Parts" production problems with a **HANNIFIN "HAN-D-PRESS"**

It's air operated!



The husky Hannifin "Han-D-Press" takes operator fatigue out of light production operations where speed is the key to economy. A safe, easy-to-operate Hannifin air-operated bench press can handle these sometimes troublesome jobs better, faster and easier.

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PUNCHING
PRESSING
ASSEMBLING
MARKING

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- Guided ram. Speed easily adjustable. Automatic return.
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CENTRAL POINT IN THE NATION FOR FLUID POWER APPLICATION

Bale Sealer

J. L. Ferguson Co., P. O. Box 1226, Joliet, Ill.—4 page pamphlet—Data on baler-bag sealer for handling any product which may be shipped with only a paper wrapping are given in Pamphlet 100-56. The four operations which it performs include folding, gluing, sealing, and compressing. A schematic diagram illustrates the floor plan and elevation of the sealer.

Circle 511 on Page 19

Process Control Instruments

Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.—8 page bulletin—Process control instruments outlined in Catalog F-5633 include recorders, controllers, indicators, combustion safeguards, sensing elements, control centers, and accessories. Application photos of the various instruments are also included.

Circle 512 on Page 19

Vacuum Pumps

Consolidated Vacuum Corp., 1755 Mt. Read Blvd., Rochester 3, N. Y.—6 page pamphlet—Line of oil-sealed rotary vacuum pumps is subject of Bulletin 8-15. The line includes 9 pumps. Single-stage pumps produce an ultimate pressure of 2 by 10^{-3} mm Hg, and two-stage pumps have ultimate pressures of 2 by 10^{-5} mm Hg. Also noted is the building block construction used in the pumps. Graphs illustrate the relationship of pressure to speed.

Circle 513 on Page 19

Panel Meters

General Electric Co., Schenectady 5, N. Y.—12 page bulletin—Line of 2½, 3½, and 4½-inch panel meters is contained in Bulletin GEA-7034. Details are given on the design of the panel meters which have a border-to-border scale. Ordering information on both ac and dc types is given.

Circle 514 on Page 19

Proximity Switch

Robotron Corp., 21300 W. Eight Mile Rd., Detroit 19, Mich.—32 page handbook—This booklet shows how to apply and install a proximity die saver switch to a press stamping operation to prevent the possibility of multiple heading. Explained in detail are the introduction of the switch to stamping press circuits, application considerations, installation and initial setup procedure, operating instructions, and electronic theory of operation. Appropriate drawings and diagrams accompany each of these steps.

Circle 515 on Page 19

Automation Tools

Buckeye Tools Corp., Springboro Pike at U. S. 25, Dayton 39, Ohio—8 page bulletin—Automation tools described in pamphlet can perform drilling, tapping, screwdriving, nut running, wire brushing, grinding, reaming, counterboring, and countersinking operations. Details are given on the 21K and 21L series, and layout tracing templates for both series are included. Tables which can be used as a guide in determining the tool and circuit for typical processes are given.

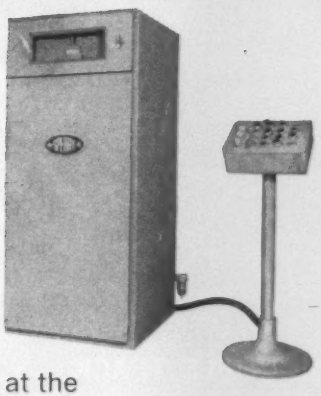
Circle 516 on Page 19

Circle 746 on Page 19

Sperry turns back the point of no return!

Tooling costs . . . up. Labor costs . . . rising. If the total cost of producing your product is reaching the point of no return, you can do something about it.

SPERRY NUMERICAL MACHINE TOOL CONTROL saves thousands, in tooling...and labor!



See it in action at the

MACHINE TOOL EXPOSITION

CHICAGO, ILLINOIS . . . and discover for yourself how Sperry Numerical Controls can apply to **your** production problems. You'll see some of the finest machine tools made — operating under the fast, accurate direction of Sperry Numerical Control.

If you cannot attend, further information can be had by writing to:

SPERRY

SPERRY GYROSCOPE COMPANY OF CANADA, LTD.
NUMERICAL CONTROL DIVISION
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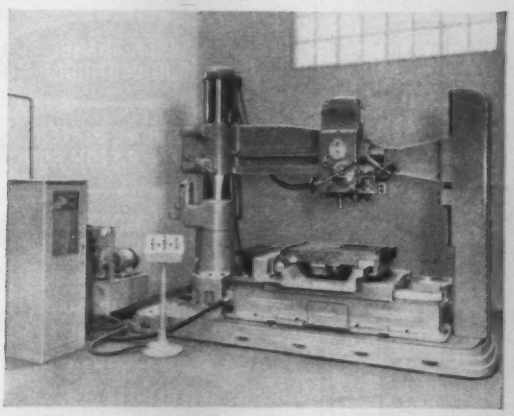
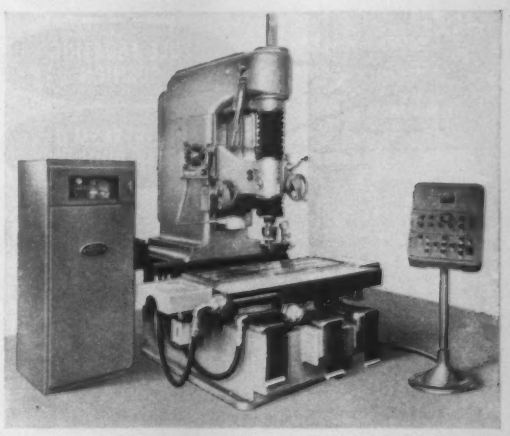


The American Tool Works Co., Boring and Drilling Machine with Ultra-Precision 30" x 30" Positioning Table shown here, provides a large, rugged work capacity and Jig Borer accuracy. Sperry Numerical Control positions both axes at high speeds, simultaneously.



Jobs formerly requiring precision jigs can now be run directly on this #65 automatic production Jig Borer by W.B. Knight Machinery Company. Positioned by Sperry Tape Control, extreme accuracy and speed is maintained constantly through the use of hydraulic cylinders and linear transducers.

WHO'S SMILING?

YOU, WHEN **YOU** DISCOVER THE DESIGN ADVANTAGES OF . . . .

LINDBERG

SQUAREHEAD CYLINDERS

DESIGN IN LINDBERG AND . . . ADD ALL THESE FEATURES!
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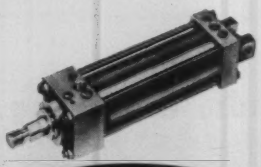

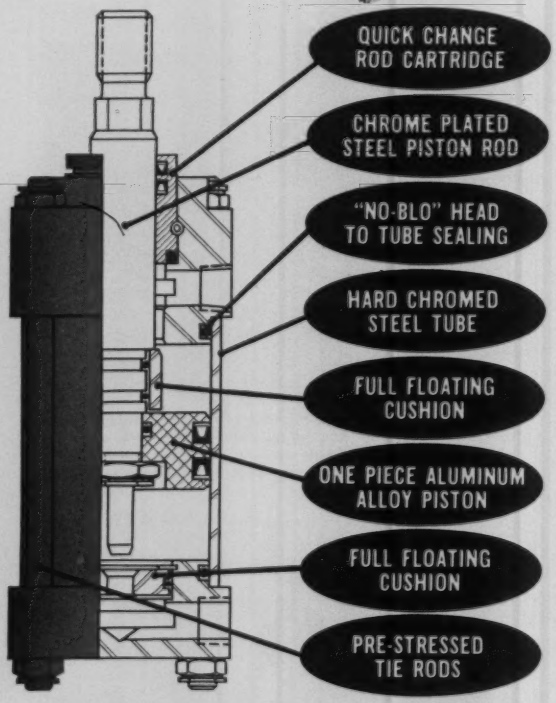
QUICK CHANGE ROD CARTRIDGE
CHROME PLATED STEEL PISTON ROD
"NO-BLO" HEAD TO TUBE SEALING
HARD CHROMED STEEL TUBE
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FULL FLOATING CUSHION
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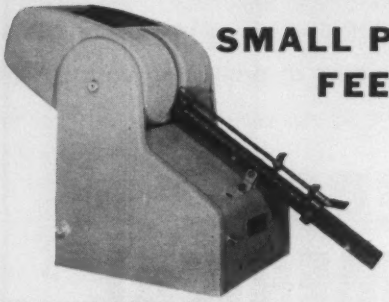
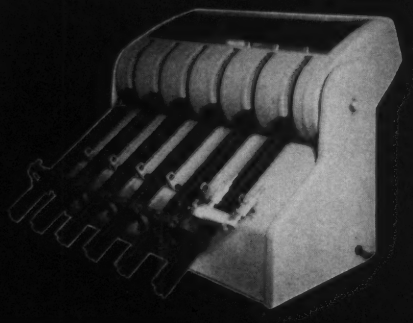


SINGLE TRACK

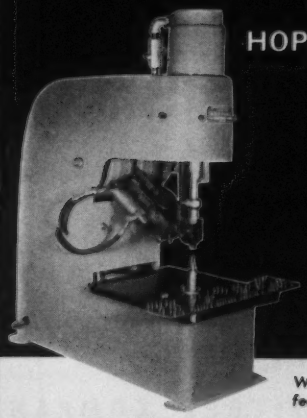
Automates your operation by continuously supplying parts which are properly oriented for machining, assembly and packaging. Gentle oscillating action of "HOPPERAL" assures trouble free feeding of parts. Unit shown has adjustable escapement to release one or more parts at a time.

REDUCE ASSEMBLY COSTS



MULTIPLE TRACK

Available with any number of tracks to feed parts to assemblies or other operations where a large quantity of parts is required simultaneously. Can be partitioned and supplied with properly designed tracks to feed unlike parts.



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A bench press with built-in parts feeder to provide a continuous supply of small parts properly oriented for staking, press fitting, peening and riveting.

The Hopperal parts feeder will feed screws, nuts, bolts, rivets, nails and other fastening devices for many assembly operations.

Write for brochure on automated feeders and assembly machines.

HABERSTUMP-HARRIS, INC.

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Circle 749 on Page 19

AUTOMATION abstracts

COMPUTER CONTROLLED PROCESS

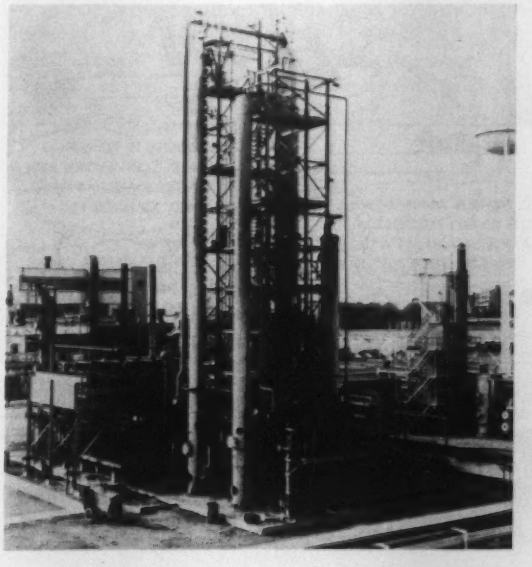
By J. M. MADIGAN
Development Scientist
B. F. Goodrich Chemical Co.
Avon Lake, Ohio

APPROXIMATELY a year and a half ago, B. F. Goodrich Chemical Co. initiated a program aimed at installing a computer to control the operation of two chemical processes at our Calvert City, Ky., plant. This system is now in its initial phases of operation. You might wonder how we arrived at the decision to embark on this more or less pioneering venture. It is a typical case history of the evaluation of any new departure. Computer control hardware was available and in fact was being actively marketed. Management decided that BFG Chemical would be the most likely place to apply this technology, and the new vinyl chloride process, which we had under development, appeared to be a likely candidate for computer control. Upon study, it was found that the same computer, the RW-300 manufactured by Thompson Ramo Wooldridge Inc., was capable of controlling two of our processes, and economic justification of the $225,000 expenditure looked promising. These particular processes produce the basic chemicals for two of BFG Chemical's most important groups of products—vinyl chloride, which is used in our Geon vinyl resins, and acrylonitrile, which is used in our Hycar synthetic rubbers.

The starting point of any capital expenditure is, of course, with economic justification. Our chemical plants were already well automated or controlled by instruments prior to development of process control computers. Typical instrumentation costs for a chemical plant presently range from 2 to 10 per cent of the total capital invested. What do we hope to gain by increasing this cost by adding a computer? We will not reduce the cost of labor. The reduction in labor occurred in our first or instrumental stage of automation. The plants that BFG is putting under computer control now require just four operators per shift. These operators will remain, with redefined roles.

What the computer does, that the operators cannot do as well, is to apply preplanned intelligence to the over-all economic operation of the process. In the general case this can result in increased production, reduced operating costs, and improved quality control. For the vinyl chloride process the latter two are our immediate goals, and for acrylonitrile all three play a part. This, in a way, has been the basis of almost all of BFG's application of computers. Efficiency in terms of inventory control and better utilization of raw materials or equipment have been our major aims, not replacement of labor.

Once we had decided that a digital computer control system could probably be economically justified, a small group of B. F. Goodrich engineers were assigned to work with the technical staff of the Thompson Ramo Wooldridge Products Co. The major task this group faced was



Chemical processing unit at left produces vinyl chloride monomer by cracking ethylene dichloride. Operation proceeds under closed-loop control of computer in control room shown below. The computer is in the foreground, the operator's console at the left, and the conventional graphic panel in the background. Besides controlling the process, the computer system scans process variables and logs readings and computed values.

the development of a practical mathematical model of the process to predict what the process will do under any given set of operating conditions, and then state, quantitatively, what control actions must be taken. The model is based on economics. It includes what is generally called an "objective equation" which expresses the profit or alternately the cost of operating the process. A profit expression is maximized, and a cost expression is minimized. The only costs that are significant are the controllable costs or those which vary with process operation. Fixed costs are not considered. Many parts of the model do not have to be precise, but it is quite important that the costs employed in the objective equation have a true relative relationship to each other.

Another important component of the math model is the "restraints" which define the limits of what the control system can and cannot do. Sometimes these are equipment limitations or the day-to-day availability of raw materials. For example, one of the restraints in our vinyl chloride control system is one of meeting, but not exceeding, a monthly production goal which is often changed during the month to meet special circumstances.

The third important set of equations in the model is the mathematical relationships between the operating characteristics and the things that can be controlled. This is usually done by setting up a theoretical model of how we think the process behaves and then fitting it to the process realities. Very few chemical processes are understood well enough to make this set of equations all inclusive. Thus, the model is tested and put into use, and the bugs eliminated by careful study of its actions. Some areas are so poorly defined that in-line changes in parts of the model are anticipated through the use of "adaptive" control. The computer periodically and automatically analyzes its predictions and updates the statistical relationships that it uses.

In the computer system that BFG is using, about 125 plant signals will be read from the two processes. These signals are automatically converted into the computer's numbering system. This is an extremely important feature of process control computers, since no program effort or computer time is required to bring in the process data. Eventually, 24 of the plant's control instruments will receive signals from the computer.

The heart of the programming system is a master program called the "executive routine." This program operates a timing diagram of all of the computer's duties. The first thing that is done in the executive routine is to check the computer by working an involved test problem. The program then checks through the timing diagram to see if it is time to perform one of its duties. For example, every five minutes we test all of the input signals against high and low limits and convert them to appropriate engineering units; every 20 minutes we calculate the new set-points for the plant's conventional controllers; on the hour we type a data log for each process; every eight hours we determine the optimum vinyl chloride plant conditions; once a day a detailed engineering analysis is made of the day's operation for both processes. These programs

"WHO SAYS THERE'S SUCH A THING AS A MAINTENANCE-FREE CONVEYOR?"
TAKE A LOOK AT CLEVELAND AND SEE WHAT YOU THINK!
EVEN DUST CAN'T GET INTO THE ENCLOSED POWER UNIT!
THERE'S ONLY ONE MOVING PART—AND IT'S AUTOMATICALLY LUBRICATED!
FLEXIBLE SUPPORTS NEVER NEED TUNING OR ADJUSTMENT!
ALL SURFACES ARE EASILY CLEANED, SAFELY TOO!
CLEVELAND CONVEYORS ARE ALL METAL. HEAT UP TO 1600° F. CAN'T HURT 'EM!
AND WHEN MAINTENANCE IS NO PROBLEM, INACCESSABILITY IS NO PROBLEM!
THAT PROVES IT TO ME... CLEVELAND CONVEYORS ARE AS MAINTENANCE-FREE AS THEY CAN GET!
WE CAN PROVE IT TO YOU TOO!
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CALL CHerry 1-7157 FOR A FEEDER OR CONVEYOR for
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every installation ...every need
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and others continue 24 hours a day, seven days a week completely automatically.

The optimization program, which is run once every eight hours, is interesting in that it comes closest to performing a true management function. Basically, it takes an over-all look at the plant economics and calculates a best set of operating conditions for this particular period. It is always working to maintain the monthly production goal. Thus, every eight hours slightly different operating conditions are fixed for the control equations. When a revised monthly goal is to be called for, a prepunched card is entered into the computer, and the process will adjust to this new condition.

Most previous examples of computer control utilized special purpose devices which were relatively inflexible. The digital computer is extremely flexible since its memory can hold any type and number of mathematical relations up to the limit of its capacity. In our system, two physically separate plants with radically different control schemes will be controlled by one on-line computer. In addition, this flexibility is almost mandatory because of the sea of ignorance which surrounds the basic mathematics of most chemical processes.

Another extremely important point concerns the basic reliability of this type of equipment. Our experience to date indicates that the introduction of transistors plus conservative design procedures can produce a computer of remarkable stability. In fact, our biggest problem of assuring continuous on-line control appears to be with our process instruments and not the computer.

To date, computer control of the vinyl chloride process has progressed to about 80 per cent of our initial goals, and the system has performed beyond our expectations. The computer and its programs have been readily accepted by the operators and the technical staff at Calvert City. Only one engineer at Calvert is assigned specifically to computer applications, and his responsibility extends well into the area of general process improvement.

From a paper entitled "How The B. F. Goodrich Chemical Co. Applies Computer Control," presented at Symposium on Computer Controlled Processes of the Chicago Section, American Institute of Chemical Engineers, February, 1960.

WHY PROCESS CHROMATOGRAPHY?

By J. E. CRAWFORD
Process Engineer
Mobil Oil Co.

WHY is process chromatography one of the decade's most outstanding money savers? Principally because it provides a simple and reliable method of continuously monitoring and/or controlling process plant operation.

What are some of the factors it can help control? First is product quality. Since variables exist in all

LIVERNOIS
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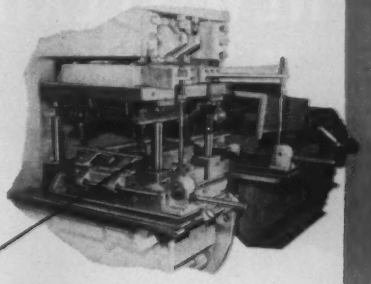
is the right move in your —

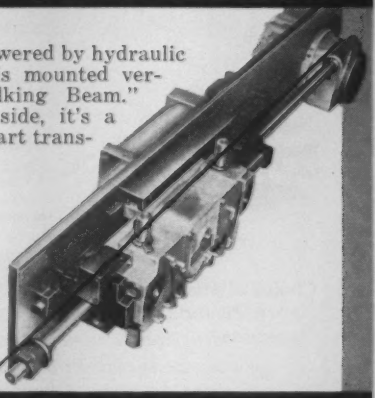
Automation with LIVERNOIS Standard Transfer Units are easily incorporated in new designs to fit large or small presses. Move any part, any distance vertically or horizontally.

Die changeover is quickly made. Economical even for low volume production on new or existing equipment.



Press application of small 3-station line transfer unit shown.

Standard unit powered by hydraulic or air cylinder is mounted vertically for "Walking Beam." Mounted on its side, it's a "Shuttle Type" part transfer unit.



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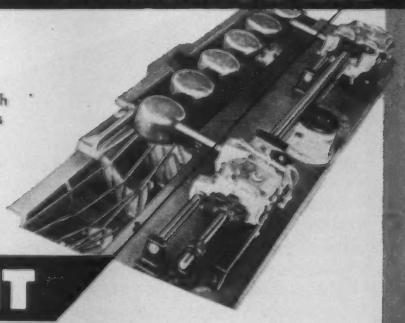

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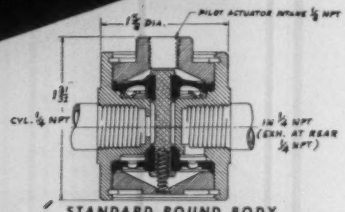

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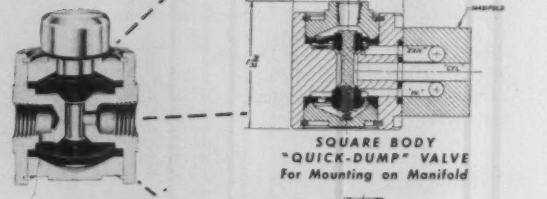

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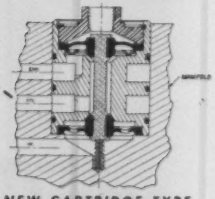

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The basic "Quick-Dump" Valve, small in size, large in capacity, lightning-fast in operation, permits endless variations in body type, methods of mounting, methods of actuating.

There are round, square, cartridge styles; 2-way, 3-way, 4-way; ⅛", ¼", ½" sizes; manual, electric, or pilot-operated. All valve air, oil, water, other liquids, gases to 125 psi. Also vacuum.

Utilizing the flexibility of "Quick-Dump" Valves, Humphrey engineers are producing a continuous flow of new pneumatic controls, both for plant processing and OEM applications.

Your control problem may also lend itself to ready solution through the use of "Quick-Dumps." Consult the Humphrey engineering department.

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operating parameters of processing equipment, and since control instruments can also impose errors, the only means of accurately assuring on-spec production is by continuously analyzing the stream. This is precisely what the process chromatograph does, presenting analyses in the control room every two to 20 minutes, 24 hours a day.

The ability to keep streams on-spec through continuous analysis also permits narrowing of product quality safety margins. A well-accepted fact is that product quality must always exceed specification. This is to insure that "upset" plant operations will not drop product quality below required purity. However, to do this, costly "enriching" ingredients must be sacrificed. If purity could be dropped only two points from 98 to 96 per cent—thousands of dollars might be saved annually on a stream having a 95 per cent purity requirement. The remaining 1 per cent safety margin could, in most plants, be maintained accurately by utilizing chromatographic data.

One outgrowth of continuous product quality analysis is the discovery of shortcomings in the process equipment itself. Frequently the reporting of changes within the process becomes so much more specific after installing a process chromatograph that improved flow, temperature, and pressure controllers are installed to cope with previously unidentified deficiencies.

Several side benefits also have been derived from continuous process analysis. Probably the most immediate of these is the reduced burden on plant-laboratory facilities. In one case, lab testing of a four-column complex dropped from 24 daily checks to only four following the process chromatograph's installation.

Another side benefit is the saving on reboiler heat. Heaters which must work at higher levels to produce large over-spec yields, may often be cut back to lower levels if the product purity requirements are reduced. If reflux is cut by 50 gallons per minute, an approximate fuel saving of $3,500 per year can be achieved. Furthermore, water cooling system requirements are reduced. Such operational economies have been observed repeatedly in plants which have adopted process chromatography.

Mobil Oil Company's Beaumont Refinery first employed a Consolidated Electrodynamics Corp. process chromatograph on its Alkylation Unit No. 1, to monitor the bottoms of the deisobutanizer. Amount of revenue from this operation is based on a balance between increasing the normal butane, which is recycled as a dilutent to the alkylation unit, and decreasing the isobutane in the normal butane, which is used for gasoline blending. Deviation by more than 2 per cent from optimum operation results in large dollar losses. Actually this tower operated in the optimum range about 60 per cent of the time before installation of the process chromatograph. Now, with continuous analysis of this stream, the tower can be operated in optimum range more than 78 per cent of the time, resulting in a savings of several thousand dollars per month.

A whole new field for process chromatography is developing in the petrochemical industry. Here, expanding demand is creating the need for new plants and increased production from existing facilities. Close control will help eliminate the need for expensive

Circle 752 on Page 19

overdesign of plants to assure on-spec yields. Continuous monitoring will also help increase existing production by reducing costly time and materials consumed in grossly over-spec operation.

Predictions of future benefits from process chromatography are even brighter than the outstanding record of achievements this instrumentation has already compiled. Automatic process control, the century-old aspiration of the process industry, will soon take a giant step forward based upon process chromatographic systems. A newly developed adaptation of both chromatograph and process controller has overcome the problems inherent in the chromatograph's intermittent operation. It is predicted that by early 1960 the first full-scale plant-control operation using this system will be functioning.

From an article, "Economics of Process Chromatography," in CEC/Recordings, Vol. 14, No. 1, First quarter, 1960, published by Consolidated Electrodynamics Corp.

CONTROLLING HYDRAULIC SYSTEMS

By C.O. BREITSPRECHER
Chief Application Engineer
Hydraulic Div.
Racine Hydraulics & Machinery Inc.
Racine, Wis.

BASIC OBJECTIVE of an engineer, in designing a hydraulic system, is to select components designed to give the greatest efficiency and economy to the machine. There are three general types of systems which have become commonplace in the evolution of oil hydraulic equipment and controls: 1. Constant displacement systems. 2. Variable-volume open systems. 3. Variable-volume closed systems.

The first of these types, possibly the most commonly used, consists of a constant-volume pump with a multiplicity of valves to control direction of flow, rate of flow, and pressure within the oil hydraulic system. To obtain control with this type of system, it is necessary for the pump to supply more oil at a higher pressure than maximum conditions require. In order to serve their function, all control devices operate at a lower value than the supply available.

The next type of system for consideration employs the principle of varying the volume of a unidirectional pump to effect simplicity and efficiency. The advanced control techniques of this method allow higher system efficiency and provide greater simplicity by eliminating flow rate and pressure-control valves, even though directional-control valves are still necessary. This system utilizes a variable-volume pump either of vane or piston construction.

The ultimate goal in system control is a reversible variable-volume pump, eliminating all system valving. This type of circuit performs equivalently to the unidirectional variable-volume pump system in terms of efficiency and accuracy and adds to system simplicity. Variable-volume pumps of piston type construction are used and normally have a small built-in gear-type pump which replenishes oil to make up for internal

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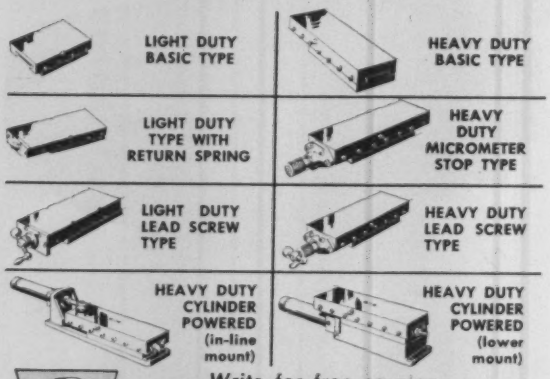
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leakages of the system. All controls for direction of flow, flow rate, and system pressure can be contained within the pump housing, making a neat, compact system. Since circulating oil is needed only for the replenishment of pump flow rate and system leakage, the variable-volume closed system uses small reservoirs.

Variable-Volume Controls

Pressure compensating: One of the most popular of the many control devices available for variable-delivery pumps is the pressure-compensating or pressure-maintaining control. The basic purpose of this control device is to provide adjustable control of the maximum system pressure and automatic control of volume to match exactly the system requirements. The automatic cutback of all or any part of the pump delivery reduces power consumption. This principle constitutes one of the most important advantages of the variable-volume pump.

The pressure-compensating pump control system is widely applied because it provides an economical system with high-circuit efficiency. However, losses attributed to pressure drop elsewhere in the system may still occur.

Pressure compensating, unloading: Dual pressure control of a variable-volume pump in hydraulic circuits affords the designer a number of desirable possibilities for a superior system. The advantages permitted by having available two selections of pressure from one pump are:

1. Increased life of the pumps and other circuit components through reduction of pressure when not required.
2. Less heat generation as a result of less total leakage in the system.
3. Reduced horsepower consumption.
4. Remote control of two preselected pressures.

The operation of this control device is basically the same as the pressure-compensating control previously discussed. Variable-volume characterstics for both the low and high-pressure settings are obtained. These two-pressure controls can provide an extremely efficient method of unloading a circuit to gain life and prevent the oil from overheating. Pumping only the amount of oil required for system leakage at low-pressure is many times more efficient than pumping full delivery at the same low pressure.

Flow rate compensating: Many hydraulic systems require efficient and accurate control of flow rate under wide variations of load and, in some cases, with varying pump speed. This can best be accomplished with an infinitely variable pump and adequate control of the pump flow rate. The control of flow at the pump permits the development of the needed power to do the required work, without appreciable loss of energy.

The flow-rate compensating control is essentially an orifice and compensator to effect control at the pump. Operation is such that oil, discharged from the pump, passes through the orifice which can be fixed or variable. Pressure difference is sampled at each side of the orifice and connected to a differential piston.

Extremely small changes of flow across the orifice can be sensed and compensated for effectively. Constant

flow is maintained regardless of pressure level at the pump and will also be maintained within the pump's displacement limitation when drive speed of the pump varies. The pressure level of the system is always equal to the exact pressure requirements to perform work plus minor line losses and control orifice pressure drop.

Flow rate and pressure compensating: Pressure protection is built into one type of flow rate and pressure compensating control by adding a small direct-acting relief valve in the upstream, pressure-sensing line. This relief valve opens when pump pressure exceeds a spring setting, thereby holding the downstream sensing-pressure constant at the preset maximum value. As system pressure continues to rise, forces opposing the relief valve pressure increase sufficiently to cause the pump pressure ring to shift until the flow rate reduces sufficiently to maintain the maximum system pressure.

A variable orifice may also be used to establish the desired pressure-compensated feed rate. Bypassing the orifice by opening a 2-way valve allows full pump delivery to go to the cylinder for rapid traverse and return. By venting the control, power consumption and heat generation during idle time are reduced to a minimum value. Extreme accuracies are possible with this system since very high system efficiency is related directly to good system temperature control. With very little temperature change, feed rates will remain stable.

A second novel technique for attaining pressure and flow rate compensation involves a design which is basically a constant-volume pump. The construction of this pump employs radially-located pistons, each having its own set of inlet and outlet check valves. The pistons are stroked by an eccentric shaft, causing an intake and discharge cycle of each piston for each revolution of the shaft.

Each piston is forced to follow the eccentric shaft motion by a calibrated spring. By introducing a controlled pressure into the pump crankcase, this pressure will act on the foot of each piston, tending to offset the force of the spring. By properly adjusting this control pressure in relation to the spring rate, the stroke of the pistons can be controlled. Established flow rates by this technique are extremely accurate.

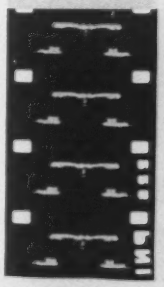
Infinitely-Variable Controls

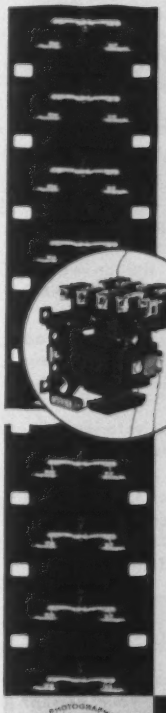
Servo positioner: The two basic types of controls discussed thus far are automatic pressure or flow-control devices which respond to preset conditions. In many applications it is necessary to have automatic infinitely variable pressure or volume. With the variable-volume pump, this can be accomplished by cams, gears, linkages, electric motors, and other means. Heavy forces within the pump, however, make these methods expensive and cumbersome, and present accuracy problems. The heavy forces within the pump can be overcome and extreme accuracies obtained by use of a hydraulically operated, mechanically controlled servo positioner.

The servo positioner is basically a device in which a built-in power ram follows the exact stroke of the servo valve spool. Hydraulic energy is used to gain mechanical advantage, and small forces on the spool can

How Allen-Bradley uses *FASTAX* to check super-speed components

Actual reproductions from FASTAX high-speed films, taken at 7,500 frames per second, used to analyze contact operation.





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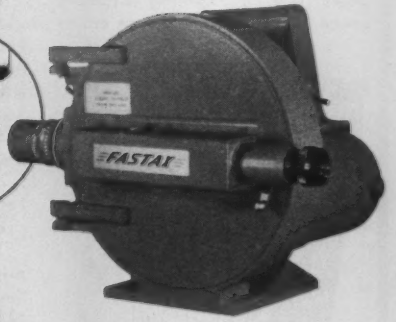

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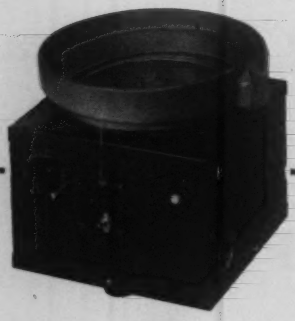

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position the pump pressure ring easily, quickly, and accurately.

This type of control is normally used on an open loop system where the flow or pressure level is controlled by one or more command signals. Open loop circuitry, using this device, must contend with pump efficiency losses and other component efficiencies unless automatically compensated for by means of an error feed back signal.

Electric motorized positioner: The next step towards infinitely-variable control combines electrical signals with mechanical positioning. This device is an electric motorized positioner which can be programmed easily and economically.

This position device is an excellent economical method to gain very accurate controllability for oil hydraulic closed-loop power systems. The command signal is constantly compared with the final result, and any error which has taken place gives a correction signal to the positioner to achieve extreme accuracy. Signal devices, such as tachometers; temperature, flow-rate, liquid level, pressure, weight, strain, or thickness sensors; indicators; or recorders can all be used as feedback signal devices. Control of tension, weight, speed, register, thickness, temperature, flow rate, and liquid level are only a few of the applications.

Directional Control: When a pump is used to control direction of actuators, a variable-volume closed system is utilized. A position-type, variable-volume pump, constructed so that the flow rate through the pump can be reversed, is the basic unit for the circuit. Both ports of the pump are directly connected to the two ports of the actuator. A small fixed-displacement pump is used to prime the system as well as to provide control pilot pressure and to compensate for leakage.

Electronic Control: With electronics, it is relatively simple to build in various types of control characteristics in either simplified or complex form. Electronics are sensitive to extremely small forces and minute changes. Electrohydraulic servo valves have high-pressure losses. It is, therefore, advantageous to use servo valves at as low a power level as possible. The logical point of application is at the variable-volume pump with the servo valve controlling pump ring or piston stroke.

The servo valve is used to port oil under pressure to one end of a cylinder. The force derived from the cylinder piston is used to drive the pump ring. Pressure oil for cylinder operation is obtained from a separate pilot pump to assure an adequate constant supply.

Feedback information can be added to the control loop at the point where power is supplied to the load. A tachometer generator, coupled directly to the fluid motor shaft, might supply a speed signal which is then compared to the command. Any difference between the feedback signal and command signal automatically calls for correction. In this way pump and fluid motor leakage losses and any other influencing factors will be corrected. By adding an integrating amplifier, the accuracies of speed regulation can be better than plus or minus 0.8 per cent.

From a paper entitled "Variable Volume Pumps and Governing Principles," presented at 15th Annual Meeting of the National Conference on Industrial Hydraulics, Chicago, October, 1959.

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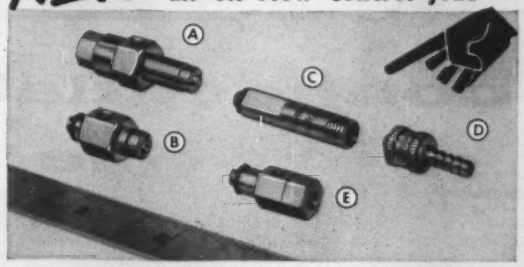

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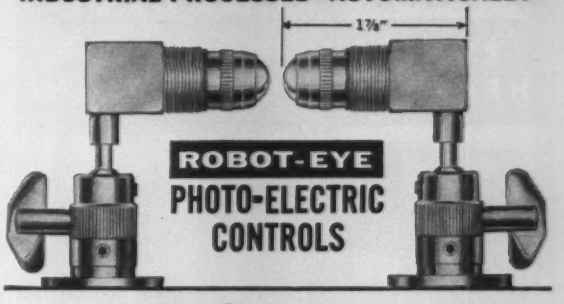

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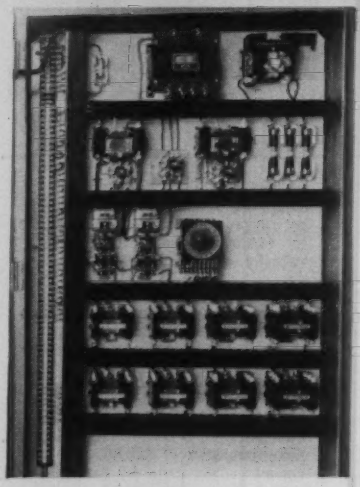

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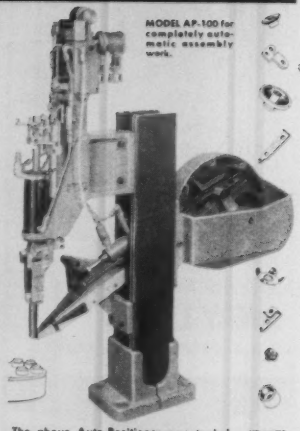

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Circle 764 on Page 19

are you stuck?

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Readers with problems concerning systems, equipment, or components for automated operations are invited to outline them to: The Editor, AUTOMATION, Penton Bldg., Cleveland 13, Ohio. Readers having solution suggestions are invited to submit them and should refer to case number and title of the problem involved. Dates shown with suggestions indicate issue in which the problem was presented.

CASE 2171-P

CEMENT DISPENSER

. . . I am looking for a piece of equipment that will dispense wet cement in a definite metered amount. In my particular case, I would like to meter, either manually or automatically, 50 cc. I would appreciate any assistance. . .

Manufacturing Engineer

CASE 2172-P

THICKNESS GAGE

. . . We are looking for a manufacturer of a thickness gage to measure the thickness of nonmetallic enamel coating on metal. The gage is to be used for nondestructive testing and should utilize either electronic or magnetic principles in measuring thickness. . .

Plant Supt.

SUGGESTION FOR 2022-P (JUNE 1960)

BOTTLE ORIENTING

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SUGGESTION FOR 2024-P (JULY 1960)

INDEXING DEVICE

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E. Gordon Reader
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SUGGESTION FOR 2170-P (JULY 1960)

LOADING SMALL DRILLS

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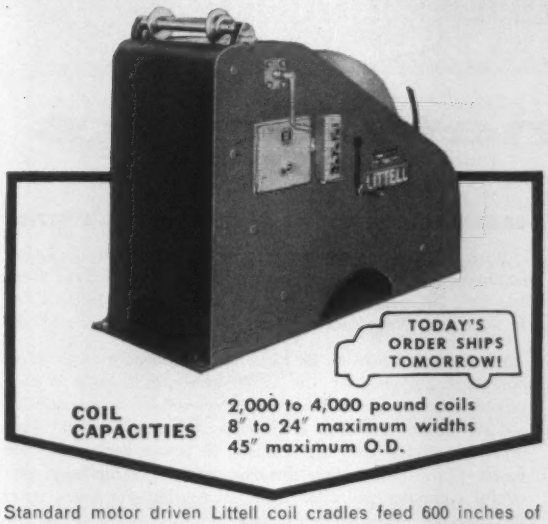

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Circle 765 on Page 19

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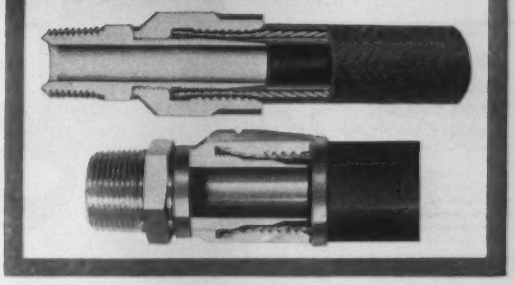

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Circle 767 on Page 19

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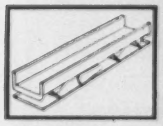

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new books

ECONOMIC CONTROL OF INTERCONNECTED SYSTEMS

By L. K. Kirchmayer, manager, system generation analytical engineering, electric utility engineering section, General Electric Co.; 207 pages, 6 by 9 inches, published by John Wiley & Sons Inc., New York; available from AUTOMATION; $12.50.

A companion book to an earlier work (*Economic Operation of Power Systems*) by the same author, this book is concerned with optimum economic operation of interconnected electric utility systems. It develops the mathematical concepts underlying computer control of power generation and power flow. The author describes various examples of successful computer-controlled installations that are based upon the theories presented in the text.

ELECTRON TUBE LIFE FACTORS

Edited by Craig Walsh and T. C. Tsao; 173 pages, 8½ by 11 inches, published by Engineering Publishers, P. O. Box 2, Elizabeth, N. J.; available from AUTOMATION; $9.50.

Sponsored by the Electronic Components Research Dept. of the U. S. Army Signal Research and Development Laboratory, a life test study was conducted by General Electric Co. and Burroughs Corp. The tubes, 35,000 in all, were tested for periods of time up to 5000 hours in order to determine changes in properties under various conditions. This book is a summary report of the findings of the test program.

ELECTRONIC CIRCUITS, SIGNALS, AND SYSTEMS

By S. J. Mason, professor of electrical engineering, and H. J. Zimmermann, professor of electrical engineering, Massachusetts Institute of Technology; 616 pages, 5¾ by 9 inches, published by John Wiley & Sons Inc., New York; available from AUTOMATION; $12.50 *postpaid.*

This book is part of a series prepared by the faculty of the Department of Electrical Engineering at M.I.T. and known collectively as the "core curriculum." It is a companion volume to *Electronic Circuit Theory*, previously written by the same authors. In this volume the authors discuss methods for analyzing and synthesizing general circuits, developing a background for more advanced system studies.

MANAGING THE MATERIALS FUNCTION

Available from American Management Association Inc., 1515 Broadway, New York 36; 131 pages, 6 by 9 inches, illustrated; $3.75.

Papers originally presented at an AMA conference on "Integrated Materials Management" (New York City, March 1959) are included in this report. The subject is divided into two sections: Materials Management in Concept and Practice, and Some Materials Management Tools. A special section discusses the problem of purchasing-engineering conflicts in materials management.

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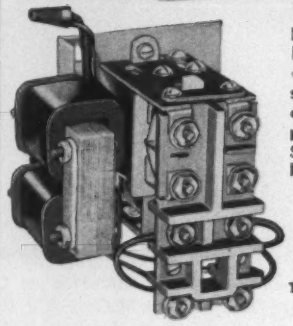

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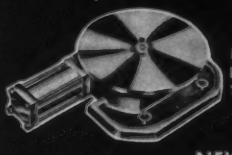

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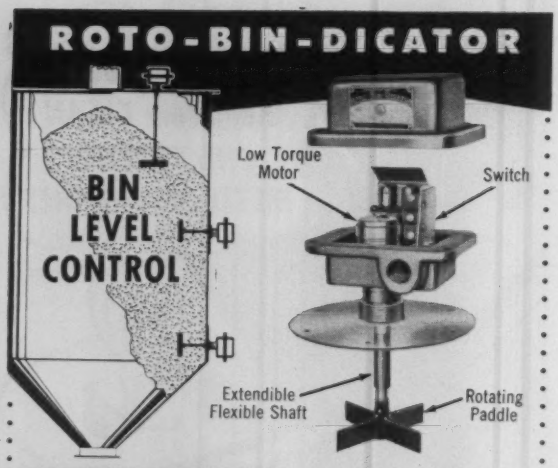

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AC MOTOR-CONTROL FUNDAMENTALS

By R. L. McIntyre, training director, Joint Apprenticeship and Training Committee for the Electrical Contracting Industry; 248 pages, 6 by 9 inches, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; $5.95.

Designed for use as a text in apprentice and industrial training programs, this book discusses motor controls in easily understood terms. The arrangement of chapters follows a system of study that has been developed and tested by the author over a 15-year period in teaching the subject. His approach is to develop an appreciation of various control components and their general characteristics, and to build on this base by proceeding to a discussion of circuit diagrams, maintenance, and trouble-shooting. Several chapters on static control elements are included.

ANALOG COMPUTATION

By Albert S. Jackson, manager, data processing and controls department, Thompson-Ramo-Wooldridge Products Co.; 652 pages, 6 by 9 inches, published by McGraw-Hill Book Co. Inc., New York; available from AUTOMATION; $13.50.

Book covers such subjects as: Basic analog computer, amplitude and time scale factors, solving ordinary linear and nonlinear differential equations, simulation, role of analog computations in operations research, computer components, and digital techniques applied to analog computation. It is the author's intention that a reader will not require a specialized background in electronics to follow the text. Where applicable, comparisons are made between the merits of computation as performed by digital computers and analog computers.

PROGRESS IN NON-DESTRUCTIVE TESTING, VOL. 2

Edited by E. G. Stanford, head of Physics Div. and J. H. Fearon, head of Information Dept., Aluminium Laboratories Ltd.; 250 pages, 6 by 9¾ inches, published by Macmillan Co., New York; available from AUTOMATION; $12.00.

The editors have undertaken the review of the general area of nondestructive testing on an annual basis, this being the second critical review in the proposed series. Seven specific topics are covered: Radiology with high-energy x-rays; mechanical testing of high polymers; electrical methods for flaw detection in metal structures; use of radioactive isotopes; ultrasonic testing; use of anelastic measurements in the study of aging and precipitation in metals; and paramagnetic resonance testing.

INDUSTRIAL ELECTRONICS AND CONTROL

By Royce G. Kloeffler, professor of electrical engineering, Kansas State University; 540 pages, 5¾ by 9 inches, published by John Wiley & Sons Inc., New York; available from AUTOMATION; $10.00.

This is a second edition, the original book having been published in 1949. As an engineering text, it is directed to mechanical, chemical, and industrial engineers requiring some knowledge of the application of electronic components and equipment in industry. Following eight chapters devoted to a discussion of fundamental concepts, the author highlights such areas as: Principles of control and servomechanisms, control of dc motors, resistance welding, high-frequency heating, and electronic instruments.

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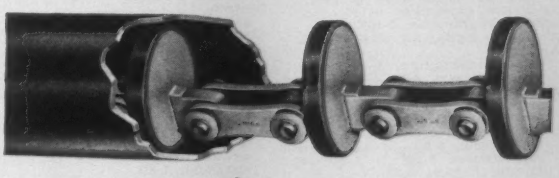

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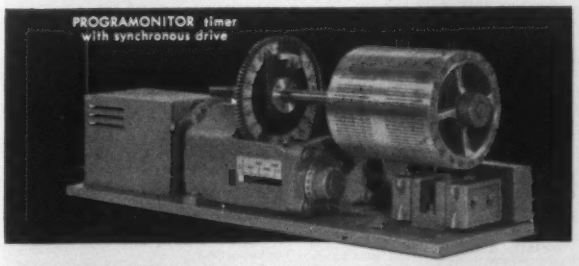

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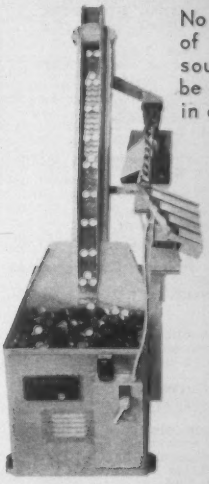

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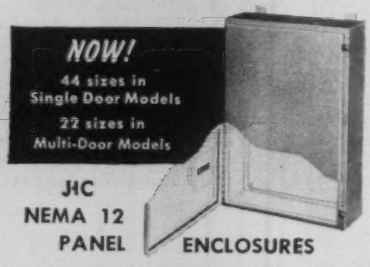
Hoffman
ELECTRICAL ENCLOSURES?



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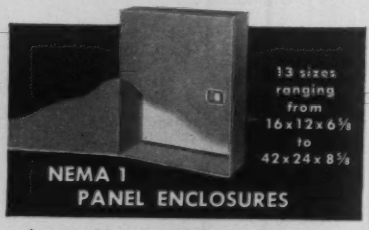

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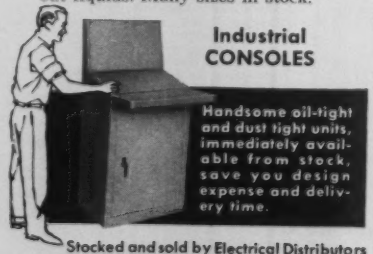

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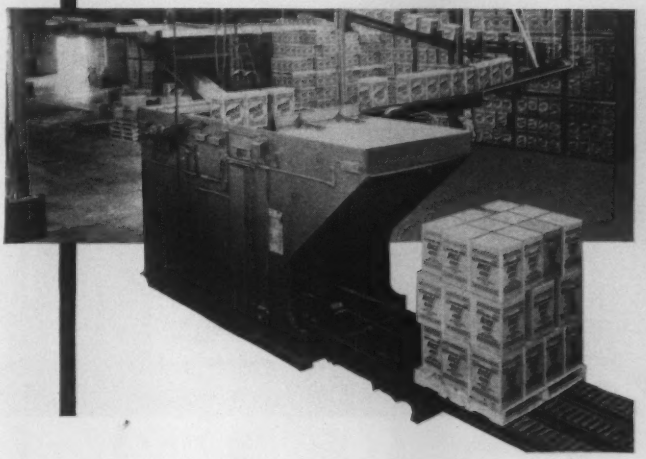
...with a LAMSON AUTOMATIC PALLET LOADER



Palletizes cartons, cases, rigid bags quickly, economically

Referred to as the "perfect link between packaging and warehousing," the LAMSON AUTOMATIC PALLET LOADER is acclaimed as a huge, money saver by leading producers of package products.

Man hours per pallet load are cut. Considerable saving occurs in the reduction of damage or breakage to cartons. Valuable men are freed for other important duties.

These reductions have been more than enough to amortize the entire cost of the LAMSON AUTOMATIC PALLET LOADER.

The introduction of the Automatic Pallet Loader was another LAMSON first in the materials handling field. A result of the ceaseless engineering vitality of LAMSON men firmly based upon 75 years of experience.

Why not bring your materials handling problems to the leaders in the field? Write LAMSON today for the name of your nearest Field Engineer. Or, simply clip this advertisement to your letterhead and mail to:

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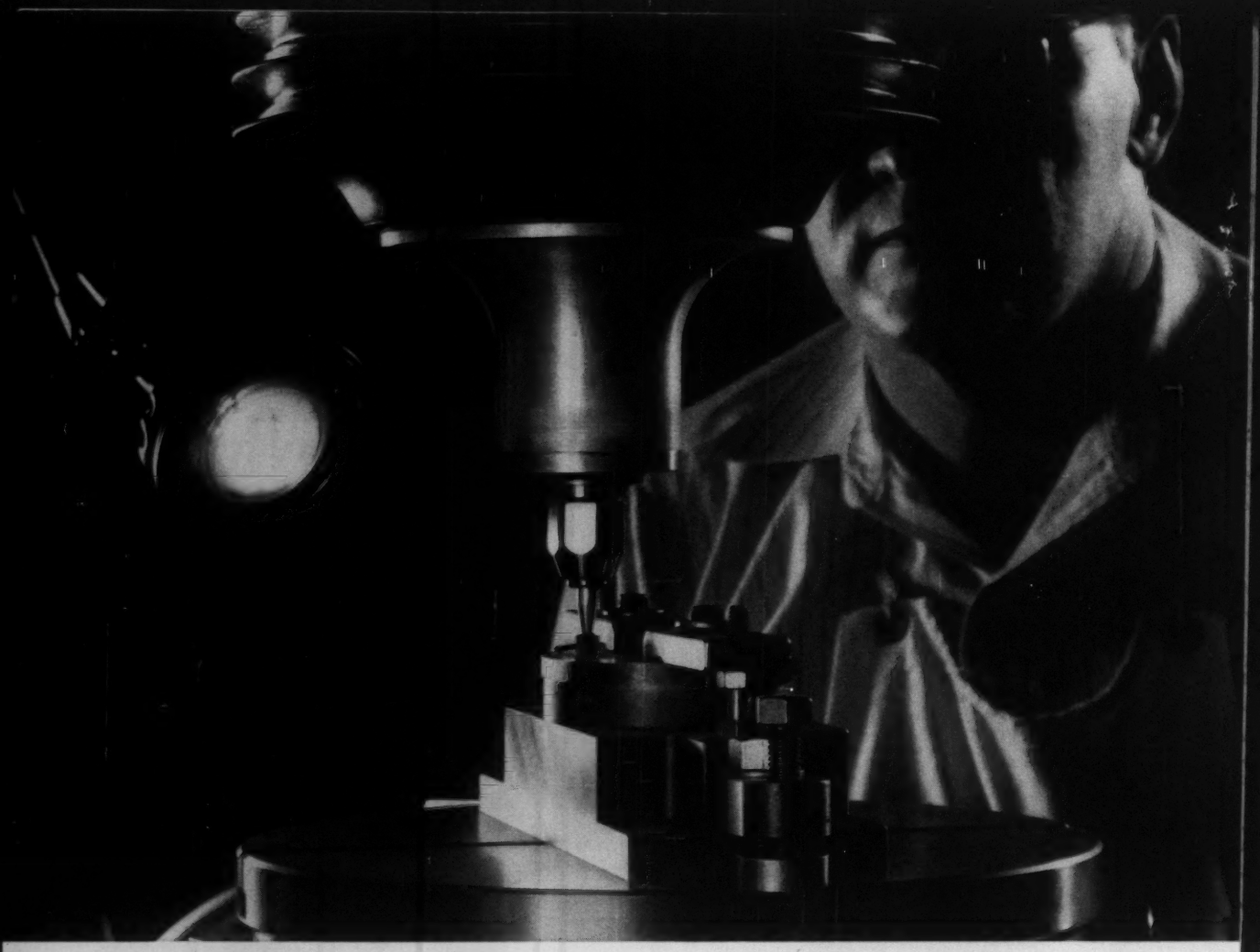

Teletype manufactures for continuous performance

Continuous performance is traditional with Teletype message and data communications equipment. For example, a Teletype Model 28 printer—test-run on a round-the-clock basis at 100 words per minute—operated continuously, hour after hour, for a total of 1,500 hours, printed 9,000,000 words! At the end of this exhaustive test, the machine was still functioning smoothly and steadily.

In maintaining its tradition of quality, Teletype's manufacturing methods play a major role. Specialized machine tools, like the jig grinder shown above, selective heat-treating processes, electronic measuring devices—these are part of a manufacturing technique that insures consistent quality.

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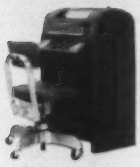
Typing Tape Punch

Tape Reader



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Automatic Send-Receive Set

FREE Model 28 line folder. Write Dept. 25H, 5555 Touhy Avenue, Skokie, Illinois.

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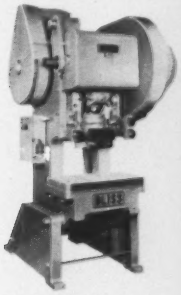
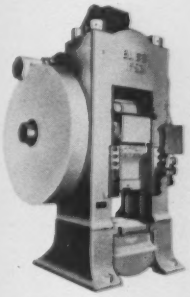
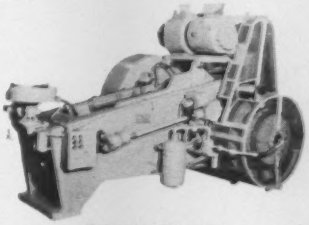
Why do more people buy BLISS presses than any other make?



Inclinable Presses
single crank and double crank



Knuckle Joint Presses



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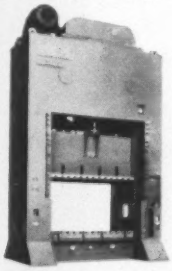
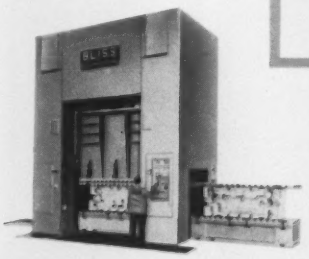
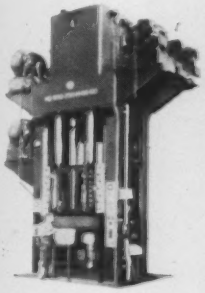


Eccentric Presses



Rolling Bolster Presses



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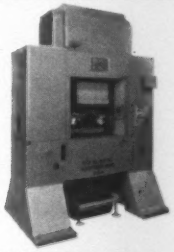

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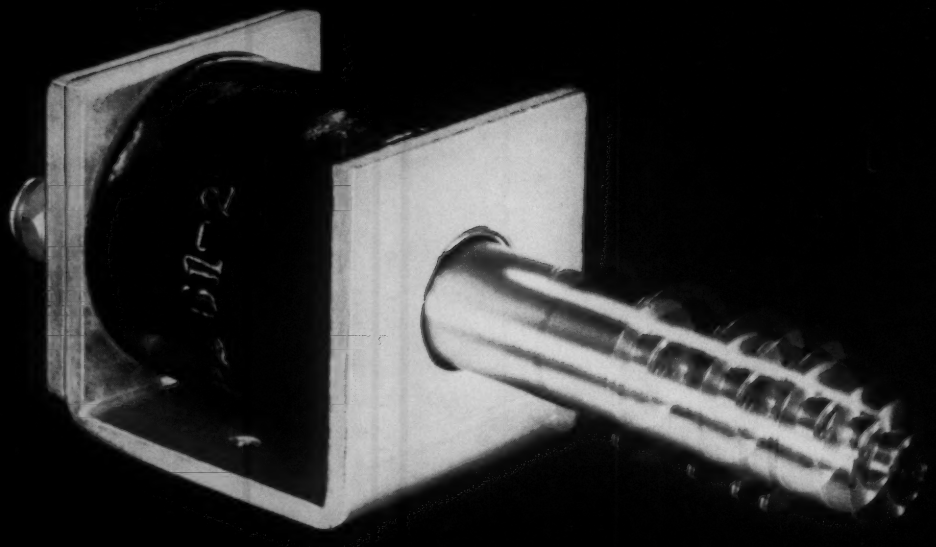

new ASCO solenoid has virtually unlimited life!

This is ASCO's new long-life solenoid. Unlike ordinary solenoids where plunger rides loosely in the sleeve this device is precision manufactured to tolerances of ± .0005". A rugged machine tool bearing guides plunger to provide accurate, smooth stroking. There is virtually no wear—almost unlimited solenoid life.

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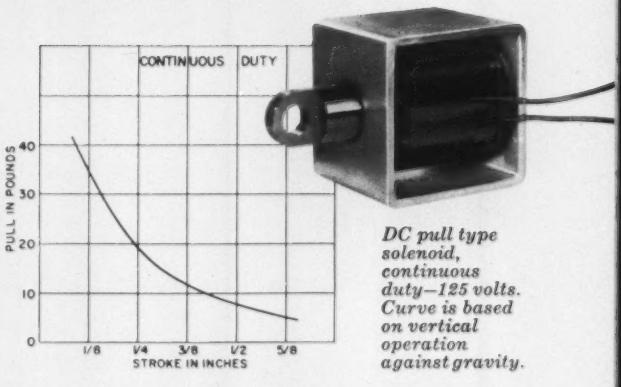

DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

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